SECOND
REPORT

OF THE

DEPARTMENTAL COMMITTEE

APPOINTED TO ENQUIRE INTO THE

VENTILATION OF FACTORIES AND WORKSHOPS;

PART I.—REPORT.

Presented to both Houses of Parliament by Command of His Majesty.

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NOTE.

This Committee was appointed in July, 1900, by the following Minute :—

> "I appoint Dr. JOHN SCOTT HALDANE, F.R.S., and Mr. E. H. OSBORN, Engineering Adviser to the Chief Inspector of Factories, to be a Committee to inquire into and report upon (*a*) the means of ventilation in factories and workshops, with especial reference to the use of fans ; (*b*) the use and construction of respirators for the protection of workpeople exposed to dust or dangerous fumes."
>
> "I appoint Mr. C. R. PENDOCK, Inspector of Factories, Secretary to the Committee."
>
> "(Signed) M. W. RIDLEY."
>
> "Whitehall, 13th July, 1900."

The First Report of the Committee was issued in August, 1902 (Cd. 1302).

In October, 1902, Dr. James Ritchie, Reader in Pathology, Oxford, was appointed an additional member of the Committee by the following Minute :—

> "I hereby appoint JAMES RITCHIE, Esq., M.D., to be an additional member of the Committe which is now enquiring into the Ventilation of Factories and Workshops."
>
> "(Signed) A. AKERS DOUGLAS."
>
> "Whitehall, 28th October, 1902."

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SECOND REPORT OF THE DEPARTMENTAL COMMITTEE APPOINTED TO INQUIRE INTO THE VENTILATION OF FACTORIES AND WORKSHOPS.

TO THE RIGHT HONOURABLE HERBERT JOHN GLADSTONE, HIS MAJESTY'S PRINCIPAL SECRETARY OF STATE FOR THE HOME DEPARTMENT.

SIR,

WE have the honour to submit to you our Second Report, which deals with the application of fans to factory ventilation, in connection more particularly with the removal of dust, fumes, steam, and other impurities associated with special manufacturing processes: also with the question of respirators. In our First Report we dealt with the removal by general ventilation of the more ordinary impurities arising from the presence of persons and lights.

INTRODUCTORY.

The present Report has been prepared with a view chiefly to furnishing some general guidance as to the application of fans to the ventilation of factories and workshops. Experience has shown that serious mistakes are frequently made in the design of fan ventilation; and we therefore hope that a short and elementary account of the subject, with diagrammatic illustrations, may prove of service to those owners and managers of factories and workshops who are not already familiar with the principles involved. The Appendix, prepared by Mr. C. R. Pendock, Secretary to the Committee, contains a large number of more detailed illustrations and descriptions, together with the results of experiments carried out for the Committee on the proper arrangement of branch ducts, &c.

SELECTION OF FANS.

Although fans of excellent construction, and driven either electrically or by pulleys, can now be very easily obtained, it must be clearly borne in mind that different types of fan are made for different kinds of work, so that a fan which is very well suited for one purpose may be quite unsuited for another. Broadly speaking, fans may be divided into: (1) low pressure fans, those designed for moving air against very slight resistances (the difference of pressure on the two sides of the fan not exceeding, say, $\frac{1}{4}$ inch of water as measured by a water gauge); and (2) high pressure fans, working against resistances which may mount up to several inches of water. The resistance due to the passage of a given volume of air through the fan itself is, size for size, very much smaller in the former than in the latter class. Hence, if a high pressure fan is used to drive air against a low external resistance, practically the whole of the power expended may be wasted in overcoming the internal resistance of the fan. On the other hand, if a low pressure fan be used against a high external resistance, the quantity of air passed will be very small, and the power will be thrown away in friction and the production of eddies about the fan.

Low Pressure Fans.

When air requires to be moved against very slight pressure, the so-called "propeller" fan is usually employed, although low resistance centrifugal fans can also be advantageously used in some cases. In the propeller type of fan the blades are arranged similarly to those of the screw propeller of a steamship, the air being driven forward by their revolution. (*See* Fig. 1.) By this means enormous volumes of air can be delivered through the fan with a very small expenditure of power, provided there is little or no resistance on either side. For a good type of propeller fan working under practical conditions, with unimpeded flow of air, Mr. W. G. Walker gives the following convenient formula as the result of a number of experiments :—

$$\text{Horse-power} = \frac{Q^3}{D^4} \times 0{\cdot}0000115 \; ;$$

Where Q = Quantity of air discharged in cubic feet per second, D = Diameter of fan in feet.

Thus with a discharge of 12,000 cubic feet per minute, or 200 cubic feet per second, and a four-foot fan, the horse-power required would be $\frac{200^3}{4^4} \times 0{\cdot}0000115 = 0{\cdot}35$. This example will give an idea of the very large volumes of air which can be moved by a propeller fan with a trifling expenditure of power, provided there is no resistance.

The air-delivery by a propeller fan varies in direct proportion to its rate of revolution, while the power needed to drive it varies as the cube of its velocity. Hence for a given expenditure of power much more air is propelled with a low than with a high rate of revolution. In practice, however, it is best to run a fan at a considerable velocity ; otherwise the flow of air may easily be greatly diminished, or even reversed, by the influence of wind.

With increasing resistance the air delivered by a propeller fan rapidly falls to almost nothing, although considerable power is being expended in driving it. The waste of power is due to the fact that air passes back through the centre of the fan, where the velocity of the blades is low, and the work done by the tips of the blades is absorbed in merely expelling this same air. (*See* Fig. 2.)

The resistance may be due (apart from the influence of wind or of insufficient inlet openings to the room) to constriction of the ducts, inlets, or outlets connected with the fan, to sharp bends or rectangular junctions with branch ducts, and to friction along the sides of ducts. If the sectional area at any part of a duct conveying air to or from a fan be reduced to less than the sectional area of the fan (*see* Fig. 2), it is evident that the linear velocity of the current at this point will be correspondingly greater than at other points in the duct. But the work expended in setting air in motion varies as the square of the velocity, and any considerable narrowing of a duct thus introduces a resistance which a propeller fan cannot overcome, with the result that the power applied to the fan is wasted. It is a common mistake to suppose that by constricting a duct leading to or from a propeller fan a materially greater velocity of air current can be obtained. The influence of the constriction is simply to diminish the flow of air. Another source of resistance is any sharp bend in a duct. A rectangular bend (*see* Fig. 2) practically doubles the pressure needed to merely set the air in motion in the duct, and a rectangular junction with a branch duct has a similar effect. A loss about half as great also occurs at the inlet opening of a duct unless it is trumpet shaped. Resistance due to friction along the walls of a duct is proportional to the total internal surface of the duct, and to about the square of the linear velocity, but inversely proportional to its sectional area. It becomes a serious item if long and narrow ducts are employed, and such ducts should always be avoided where propeller fans are used. Frictional resistance depends also upon the roughness of the internal surface of a duct, and these surfaces should be as smooth as possible. The narrowing of ducts by deposits of dust should also be carefully avoided, and the better to ensure this, when ducts are being constructed ample provision should be made at suitable points for the easy removal of dust and other accumulations.

Fig. 2 shows an extremely bad arrangement of ducts connected with a propeller fan. The narrowing of the duct at K reduces the flow of air to about a tenth of what it would otherwise be. A further considerable loss is caused by the rectangular bends at C and D, and at E, F, G, H, I. The size, and the arrangement at right-angles to the main duct of the branch ducts E, F, G, H, and I, is such that the air flow through them is very unequal, the flow through I being a mere fraction of what passes through E. (*See* experiments in Appendix, pp. 9 to 13.) The fan is wasting its work in churning air round, as indicated by the arrows A and B.

HIGH PRESSURE FANS.

Where air currents of high velocity are needed, as, for instance, in exhausting the dust from wheels used in dry grinding, or where narrow or tortuous ducts cannot be avoided, it is necessary to have fans capable of working effectively against considerable resistances. For this purpose centrifugal fans are usually employed. In the centrifugal fan the air inlet is at the centre of the fan, which is enclosed in a metal case (Fig. 3 and Appendix, Plates 11, 11A, 11B), and the air is driven outwards in a tangential direction by the revolution of the blades into a space between their periphery and the case. As the outline of the case is somewhat like that of a snail's shell, this space gradually increases in cross section towards the air outlet, so that the air passing outwards between the blades can escape freely at all parts of their revolution, and travel round the case to the outlet. A trumpet-shaped prolongation of the latter increases the efficiency of an exhaust fan (see Appendix, Plate 11B, Fig. 1).

According to the details of construction centrifugal fans may be suited to deliver, with a given expenditure of power, either large volumes of air against a relatively low resistance, or smaller volumes against a relatively high resistance ; and in selecting a fan the volume of air required, and the resistance against which it has to work, must be carefully considered. Centrifugal fans suited to work against the higher resistances have also a relatively high internal resistance, so that if they are set to work against a low resistance in ducts, &c., the energy is wasted on the internal resistance. Details with regard to the capacities of various types of fan may be obtained from the makers, who should specify the volumes of air delivered, as measured by an anemometer, with different resistances measured by a water-gauge, together with the corresponding horse-powers required to drive the fan.

The resistances which have to be overcome by pressure fans are of course due to the same causes as in the case of propeller fans ; but in practice the factors involved often differ in relative importance in the two cases. Thus the ducts connected with a pressure fan are usually longer in proportion to their cross section, so that resistance due to friction is more important. There may also be many unavoidable bends in them. They are usually best made of metal pipes with smooth internal surface, all sharp rectangular bends or junctions being avoided and no leakage permitted : unless these points are attended to, resistance due to friction, &c., may mount to a very serious extent. On the other hand the comparatively small resistances due to such causes as wind-pressure, restricted inlet openings to a room, &c., are of much less importance than when a propeller fan is used.

VOLUME OF AIR REQUIRED, AND ARRANGEMENT OF INLETS AND OUTLETS.

In designing any system of fan ventilation the first points to consider are the quantity of air required and its proper distribution. The quantity depends to a large extent on the distribution ; and in many cases a relatively small quantity well distributed is far more effective than a large quantity badly distributed.

A.—*General Ventilation.**—Certain impurities can hardly be prevented from becoming generally distributed in the air of a room, and can thus only be dealt with by *general ventilation* of the room. In most cases this is true of the products of respiration and of combustion of gas, the water evaporated in wet processes, and the heat given off from moving or artificially heated machinery; and in some cases of the production of dust. In removing these impurities or sources of inconvenience the supply of air must be sufficient for the particular purpose in view. If, for instance, heat or dust has to be removed, the ventilation must be sufficient to effect this removal, and not merely to dilute the products of respiration.

As regards impurities from persons and lights, the legal standard proposed by this Committee in its first report was such as would prevent the proportion of CO_2 from respiration or combustion from ever rising beyond 12 volumes per 10,000 of air during daylight, or beyond 20 volumes at night with gas burning. If the distribution of air were perfect and constant this would imply a *minimum* ventilation by day of about 1,250 cubic feet of air per person and per hour. Since, however, the distribution is always more or less imperfect and liable to be interfered with by varying conditions of weather, about double this quantity of air would usually need to be supplied in order to conform to the standard. If more than about two cubic feet of gas per person and per hour were burnt in the room (or one flat-flame jet to three persons) an addition of about 1,500 cubic feet per hour for each extra flat-flame jet would probably be needed.

The quantity of air required to remove excessive heat and moisture cannot well be calculated in the same way, as the loss of heat through walls and roof is usually not known, and in any case varies with the weather. The air supply must therefore be regulated with the help of thermometers. Air in which the reading by the *wet bulb* thermometer exceeds about 70° begins to cause serious inconvenience with ordinary clothing, and this limit ought not to be exceeded in factories or workshops except under exceptional conditions.

Experiments show that if the wet bulb reading rises beyond about 88° in fairly still air, the body temperature can no longer be prevented from rising seriously even in persons stripped to the waist and doing no work; and with muscular work under the same conditions the body temperature may rise rapidly at a wet bulb temperature of 80°. With ordinary clothing this effect is considerably greater. At the upper limits it is not the temperature of the air, but that of the wet bulb thermometer, that matters; and provided that the air is so dry that the wet bulb temperature does not exceed the limits specified, air temperatures up to 130° or more can be tolerated without rise of body temperature.† Much higher wet bulb temperatures can of course be borne for short periods, but the body temperature soon rises seriously.

In removing steam from rooms it must be borne in mind that cold air is apt to cause condensation of aqueous vapour. Thus if air saturated with moisture at 80° is mixed with even ten times its volume of air from outside at 40° condensation will nevertheless usually occur, and will always do so, whatever the dilution, if the incoming air is saturated with moisture at the outside temperature. If, however, the incoming air be warmed to a moderate extent as it enters, this condensation will be prevented, and the ventilation will serve the double object of cooling the room and preventing condensation. If it is only necessary to prevent condensation of vapour, and not to remove heat, the object can often be best attained by providing, not extra ventilation, but heating arrangements. In the case of dyeworks, &c., where the building is often filled with steam from the vats, experience shows that the atmosphere is best cleared and condensation avoided by blowing in air heated by passing through a coil or other form of radiator. (*See* Appendix, Plate 38.)

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* A more detailed account of this subject and of the general laws of flow of air will be found in Appendix II. of the First Report of the Factory Ventilation Committee, Parliamentary Paper, [Cd. 1302], 1902.

† The following observations made recently by Dr. Haldane will illustrate this statement:—With the air temperature at 131° and the wet bulb at 88°, the body temperature remained the same after 2¼ hours. With the air-temperature at 89° and the wet bulb at 89° on the other hand, the body temperature rose nearly 3° in the same time, and with the air temperature at 94° and the wet bulb at 94° the body temperature rose 4° in two hours. The subject who was the same in each of the experiments, was stripped to the waist, and resting. With moderately hard work and a wet bulb temperature of 87° the temperature rose 4° in one hour. Further details will be found in a paper by Dr. Haldane on "The effects of high air-temperature," *Journal of Hygiene*, 1906, p. 494.

As regards removal of dust, the standard of purity aimed at should always be sufficient to prevent injury to health, and should also be such as to prevent inconvenience and enable those employed to be clean when they leave work, after washing, if necessary. Dust from the disintegration of hard stone, steel-grinding, &c., is extremely deleterious, and the same may be said of dust containing any poisonous constituent, such as lead.* In such cases the dust should, by special means, apart from general ventilation, be entirely prevented from mixing with the general atmosphere of a room ; and the same remark applies to all poisonous gases and fumes.

The effect of ventilation on the temperature of a working room during cold weather needs careful regulation. For sedentary work and fine manipulations a temperature of not less than about 60° is required. With lower temperatures the working powers of those present become impaired ; and the effcts of the low temperature are much increased by draughts. On the other hand, if the work implies active exertion lower temperatures are permissible ; and some kinds of work associated with dust, fumes, &c., can best be performed in sheds open to the air. In general, the more nearly open-air conditions can be attained to in any class of work the better ; and, whenever possible, windows should be thrown widely open in summer weather.

In general ventilation by fans the air may be either blown in (so called "plenum" system) or exhausted. The one or the other system may be most suitable according to circumstances, and in some instances the combination of both systems is desirable and most effective, as in the French or so-called dry cleaning, where the fumes of benzole, &c., require to be locally exhausted and fresh air supplied. The exhaust system is much employed on account of its simplicity, especially in sparsely occupied rooms, the air being exhausted by one or more fans placed in windows, walls, or roof, and allowed to enter by suitably arranged openings distributed at other parts of the room. The main advantages of this system are that no ducts are needed, and that the fan causes no draught in its neighbourhood, while the cold incoming air causes little draught if given an upward direction so as to mix with the warm air of the room above the heads of the occupants. A fan or exhaust opening of any kind draws its air supply from all round without causing a draught in a particular direction. When, however, air is entering through a fan or other inlet it is driven in a definite stream straight forwards owing to the momentum which has been communicated to it. *Fig. 4* shows the draughts produced on the inlet and outlet sides of an electrically-driven propeller fan. The dotted lines indicate the area within which there was a draught exceeding two feet per second. The figure is drawn to scale from actual observations.

With exhaust ventilation corresponding inlet openings are essential, apart from the chance opening of windows or doors. The inlet openings should have a total sectional area equal to or greater than the fan opening, and should direct the air upwards so as to avoid draughts. Although a considerable amount of air may enter through the walls, &c., of a room, this quantity is usually insufficient, and owing to the neglect of inlet provision exhaust propeller fans may often be seen wasting most of the power communicated to them and producing no satisfactory result. The inlets should be so placed that the whole room is properly supplied with fresh air, the incoming air not being allowed to pass straight to a fan without displacing a due proportion of the foul air of the room (*see* Appendix, Plate XII.) It is often a distinct advantage to have the exhaust outlet at the floor level. With this arrangement dust and particulate matter, including that from the mouths and persons of those present, are more effectually removed, since all particulate matter tends to fall. Loss of heat from the room is also diminished, as air at the floor level is colder. On the other hand hot air and the products of combustion of gas are best removed by an outlet opening higher up.

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* It is sometimes difficult to say whether the inhalation of a given variety of dust is definitely injurious. Dust from any hard stone (such as flint, granite, sandstone, &c.) is undoubtedly very injurious to the lungs, producing a marked predisposition to phthisis. On the other hand coal-dust, cement dust, and probably many other varieties of organic and inorganic dust have by no means the same serious effects. During our enquiry many experiments have been made by Professor Ritchie with a view to finding a means of experimentally distinguishing the more injurious from less injurious dusts, but unfortunately no satisfactory results have as yet been reached.

The "plenum" system of ventilation possesses the advantage that the incoming air can be warmed or cooled as it enters, and if necessary moistened, or filtered free from smuts by passing it through coarse jute, cotton cloth, or other efficient filtering material, placed diagonally or zigzag in the inlet duct so as to give large filtering surface. As the draught is in an outward direction at all other openings than those through which the fan delivers air, there is complete control over the quality of the air entering the room, and no chance of air being drawn in from contaminated sources. As regards the position and direction of inlets and outlets, the same considerations apply as in the case of exhaust ventilation.

B.—*Local Ventilation.*—Dust, fumes, steam and other impurities unavoidably given off into the air should, wherever possible, be removed locally, and thus prevented from mixing with the general air of the room. Ventilation with this object in view may be distinguished as "local ventilation." Local ventilation is best carried out by means of exhaust fans, which may be of the propeller type if large ducts and low velocities of air will suffice. In many cases, however, centrifugal fans are essential, and usually they are preferable on account of the liability of propeller fans to be interfered with by wind, &c. Fans used for the removal of corrosive fumes should be efficiently protected from their action (Appendix, Plate 11B). The question of possible injury to bearings or other parts by gritty material, and of possible blockage by fibrous material, should also be borne in mind in selecting a fan.

If dust or fumes are allowed to escape in any quantity into the general atmosphere of a room enormous volumes of air are required to remove or dilute them sufficiently. Great discomfort from cold, or else great expense in heating, are thus entailed, so that it is in every way preferable to remove them by local ventilation. The nearer to their points of production they can be removed the less will be the quantity of air required, and consequently the less will be the discomfort and expense which they cause.

Dusty machines which cannot be completely boxed in should, if possible, be provided with an exhaust sufficiently powerful to draw the dust from exposed parts inwards through the machine to an exhaust opening. (*See* Fig. 5.) Wheels used in dry grinding, polishing, &c., should, wherever possible, be enclosed as shown in Fig. 6 (also in Appendix, Plates 19-26), and provided with an exhaust from a centrifugal fan capable of giving a current at high velocity round the exposed part of the wheel. The part of the wheel left open should be as small as is consistent with efficient working.

Dusty operations, such as the transference and packing of dry and dusty material, should, if possible, be carried out by mechanical arrangements boxed in so as to prevent the escape of dust, and combined, if necessary, with local exhaust ventilation. This is extremely important where the material contains some poisonous or harmful substance, such as lead, bichromate of potash, powdered flint, &c. Where such arrangements are not possible thoroughly efficient respirators should be used in the case of dangerous material.

For manipulations by hand in which dust, poisonous spray, or objectionable fumes are given off, working places provided each with a separate exhaust opening, can often be arranged. The table at which the work is done has an exhaust opening cut through it or placed behind it, and so arranged that the dust arising from the work is drawn away from the mouth of the person working and into a duct placed beneath or behind the table. The provision of a hood, which may be made of glass so as not to obstruct the light, greatly helps the action of the exhaust, which must be sufficient to actually prevent the dust from reaching the mouth of the worker. (*See* Figs. 7 and 8, and also Plates 48 and 49 in Appendix .) Where the dust requires to be collected a settling chamber under the exhaust opening can sometimes be provided as shown in Fig. 8.

Where one fan supplies a series of working places it is essential that the flow should be about equal through each throat or branch duct leading to the main duct. The combined cross sections of the throats should also be not less than the cross section of the main duct, otherwise there is undue resistance. If the throats or branch ducts are at right-angles to the main duct, equality of flow through them can only be established empirically by gradually lessening the size of the inlets from the farthest towards the fan. If, however, the throats are inclined at about 30° towards the main duct the inflow of air at all inlets will adjust itself with fair uniformity and the resistance will be diminished. If the combined cross sections of the throats or branch ducts greatly exceeded the cross section of the duct, there would be much difficulty in obtaining an equal flow. (*See* Appendix, Plates III. to VIIA, with the corresponding descriptions of experiments on the arrangement of main and branch ducts.)

The sufficiency of the air-current and general arrangement should be tested with smoking paper, or by watching to see whether the dust is actually carried off in such a way as to prevent its being inhaled. Five to ten thousand cubic feet of air per hour, or even more, may be needed for each working place, according to the character of the work, the distance of the source of dust from the exhaust opening, the efficiency of the hood, &c. Either a propeller fan or a low resistance centrifugal fan may be used for exhausting.

For the efficient working of a series of exhaust openings arranged in this way a proper system of inlet ventilation is essential; otherwise draughts are produced in wrong directions, or if windows are shut the exhaust ventilation is much reduced. The air should be introduced at the back of each working place, with the inlet openings directed upwards to diminish draught. By this means each person is separately supplied with air free from dust. The incoming air will usually require to be warmed in winter by means of a heating coil placed in the main inlet ducts, particularly with sedentary work, and doors and windows should be kept shut.

In some operations, such as wool-sorting or rag-sorting, it is best to manipulate the dusty material on a flat wire grating through which air is exhausted from below. (*See* Fig. 9.) In such a case the rate of flow at *every part* of the grating must be sufficient to draw the dust downwards, and the whole arrangement, including inlet ventilation to the room must be such that this purpose is effected under all conditions.

It often occurs that a large dusty machine cannot be sufficiently enclosed for the effective application of direct exhaust ventilation, or that dusty work by hand cannot be confined to the immediate neighbourhood of an exhaust opening. In these cases air inlets and outlets should be so arranged as to carry off the dust in such a direction as to contaminate as little as possible the air in positions where persons have to be present. (*See* Figs. 10 and 11, and for contrast Figs. 12 and 13.) The most generally available plan is to have the exhaust openings in the floor round each dusty machine, or as close as possible to whatever the source of the dust may be, and to allow air to enter in an abundant stream from the roof above, warmed if necessary to prevent impact of cold draught on workers. (*See* Fig. 11.) As dust tends naturally to fall to the floor, it is best to remove it downwards unless a rapid air-current, sufficient to draw it in any direction, is available. If the machine is placed near a wall and no person is required to work between the wall and the machine, the dust may be advantageously exhausted through a fan placed low down in the wall and securely guarded (Fig. 10).

The same general principles apply to the case of objectionable fumes, gases, or vapours, including steam. Those which tend to fall should be removed downwards by an exhaust opening placed round or below the place of origin, and those which tend to rise can be removed by an opening in or near the roof just above, or, still better, by a hood (Figs. 15, 16).

It may happen that though a machine cannot be boxed in the dust produced by it comes from some particular point, where it is capable of being removed. Thus, if the dust be produced as the material is passing through rollers, as in the operation performed by a machine known as a spread board in flax spinning, exhaust ventilation applied close to each roller will remove it completely with a minimum of trouble and expense if done as shown in Fig. 17: much better so than by an ordinary hopper. (*See* Plate XXXIII.)

With regard to all exhaust openings for extraction of dust, &c., it must be clearly borne in mind that in whatever direction the opening may point the air-feed is from all round: hence the radius within which a perceptible draught is produced towards the opening is extremely limited, as is strikingly shown by Fig. 4. The air-current towards an exhaust opening cannot be directed except by cumbrous air-guides, whereas the current from an inlet can be directed just like the water issuing from a fireman's hose.

Of the latter fact hardly any advantage has hitherto been taken in connection with the removal of dust and fumes, but we are confident that many difficult cases might be successfully dealt with by utilising the momentum of air issuing from an inlet opening. If compressed air in small pipes were available, fine jets of it directed across any source of dust or fumes towards a large outlet opening would be extremely efficacious in "shepherding" the dust or fumes. The fine jets would induce a sufficient current of air to carry the dust or fumes straight from their source to the exhaust opening, and no more air would require to be exhausted than would just suffice to carry off the dust or fumes. Figure 14 and Appendix, Figure 66, Plate 21, show suggested arrangements for using the momentum of incoming air in sweeping towards an exhaust opening the dust from open grinding or polishing wheels. Figure 89, Plate 32, shows an existing arrangement for removing textile dust on the same principle. Plate 43A shows the principle applied in an arrangement (designed by Mr. Pendock) which has been found to remove most successfully the fumes from moist phosphorus paste on an open working bench. This arrangement when carefully tested with smoke, and by placing on the bench a vessel giving off hot fumes, was found to be absolutely effective. No fumes escaped upwards to the face of the person working at the bench.

In testing whether any arrangement for the local removal of dust or fumes is effective, a piece of smoking brown paper or other material held at the place where the dust or fumes are given off is very useful. The test is much facilitated by using specially prepared paper which continues to smoulder and give off thick smoke. This plan was suggested to us by Mr. H. H. Cunynghame, C.B.*

In some cases, particularly in towns, dust cannot be discharged into the open air on account of the nuisance or damage which it would cause, and must, therefore, be separated from the discharged air; for this purpose the "Cyclone Separator" (Appendix Plate 37, Fig. 102) is often extremely effective: it requires little space and is easily erected at a point either near to or remote from the fan.

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* To prepare the paper a piece of blotting paper is dipped in a solution of about one ounce of nitre in half a pint of water, dried, and then dipped in benzene in which pitch has been dissolved (a piece about the size of a walnut in half a pint of benzene). When dried this paper smoulders like touch-paper and makes thick smoke.

The dust may also be separated in a settling chamber, taking the form of a room or an out-house set apart for the purpose. In this case the addition of steam from a jet will often greatly facilitate the precipitation of light dust. Heavier metallic particles can be blown into a tank of water. A common defect in settling chambers is the neglect to provide a sufficient outlet for the spent air, by which means the whole arrangement for exhausting and settling the dust is rendered ineffective.

As it is evident that the circumstances under which fan ventilation needs to be applied vary greatly in different rooms and different processes of manufacture, we would, in conclusion, take this opportunity of pointing out the necessity of carefully considering the special conditions requiring to be dealt with in each individual case, and the desirability of obtaining competent skilled advice in all cases of doubt, or of employing, in the installation of fan ventilation, only such firms as are known to have at their disposal the requisite knowledge and experience.

The Use of Respirators.

The use of respirators capable of arresting dust is often recommended in connection with factory work as a substitute for efficient removal of dust. Experience has however shown that it is extremely difficult to enforce the use of respirators, as they are all more or less uncomfortable and inconvenient, besides being unsightly. It is also very difficult to keep respirators in working order and closely applied to the face. Often enough it is found that most of the air breathed by a person wearing a respirator leaks in between the face and the respirator, and is consequently unfiltered. This is particularly apt to happen after a respirator has been worn sufficiently long for the filtering material to become damp and clogged with moisture. Except, therefore, where dust is definitely dangerous and cannot be dealt with by exhaustion, or by using wet processes, or in other ways, we are unable to recommend the use of respirators as an alternative to keeping the air clear of dust.

For the exceptional cases in which it is necessary for men to work in air containing poisonous or otherwise dangerous dust, the mouth and nose may be kept covered by a sheet of fresh cotton wool kept closely applied all round by suitable fastenings passing round the neck. This forms a reliable and efficient respirator, and is commonly used by men who have to perform such work as the removal of arsenic from arsenic flues, or of white lead from lead chambers.

For cases where work has to be done in an atmosphere containing poisonous gases or fumes, a smoke helmet, with air supplied from outside through a pipe, may be used. The air supply should be not less than two cubic feet per minute, and may be provided either from a bellows worked by hand or from a mechanically driven air-pump or high pressure centrifugal fan. A self-contained breathing apparatus, such as is used in mines, is less convenient for factory work and more expensive.

We are, Sir,

Your obedient Servants,

J. S. HALDANE.
E. H. OSBORN.
JAMES RITCHIE.

C. R. Pendock
(*Secretary*),
17*th May*, 1907.

DESCRIPTION OF ILLUSTRATIONS.

FIGURE 1.—Propeller Fan.—The direction in which the blades (*B*) revolve is indicated by the arrow *R*, and the arrows on the driving band passing round the pulley *P*. The direction of the air current is shown by the arrows *D*.

FIGURE 2.—Arrangement of propeller fan and ducts showing a series of defects described in the text (p. 4).

FIGURE 3.—Centrifugal Fan.—*E*, inlet; *D*, outlet; *F*, case. The direction of revolution is shown by the arrows on the driving band. If the fan is made to revolve in the opposite direction its efficiency is greatly diminished, but the air is still driven in the same direction.

FIGURE 4.—The dotted lines mark out the areas within which a draught exceeding 2 feet per second was found to exist on the intake and discharge sides of a propeller fan. The arrows show the direction of the air current. It will be seen that this area is enormously greater on the discharge side. Owing to the momentum which air acquires in passing through an opening, draughts in a room are felt at a long distance from an inlet opening, though they are imperceptible a short way from an outlet opening.

FIGURE 5.—Section of a dusty rag-tearing machine, cased in, and provided with an exhaust fan for removing the dust.

FIGURE 6.—Hood and air-exhaust arrangement for a grinding wheel (*W*). Part of the hood (*C*) is removable, and can be rotated on the hinge *H*.

FIGURE 7.—Working places (*W*) provided with glass-covered hoods (*H*) and exhaust openings for ground-laying in pottery work. The air is exhausted by the fan *F* from a main trunk beneath the working bench.

FIGURE 8.—Arrangement for "flat-knocking" in pottery work. For the purposes of knocking off loose flint dust the ware is inserted through the opening *A*, which is provided with a cloth curtain. The dust falls to the bottom of the box. To further guard against escape of dust a feeble current of air is drawn through the box and along the duct *D*.

FIGURE 9.—Exhaust ventilation of a rag-sorting bench. The dust formed in the manipulation of the material is drawn downwards in the direction of the arrows.

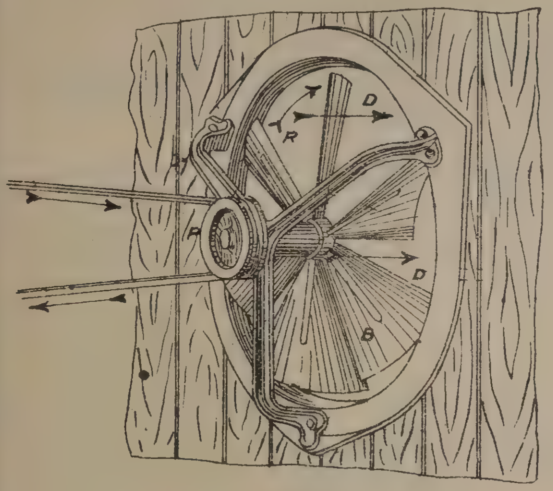
FIGURES 10, 11, 12, 13.—Figures 10 and 11 show effective methods of ventilating a room used for a dusty process. The workers are enabled to breathe pure air. Figures 12 and 13 show ineffective methods. The dust is carried towards the workers, who thus breathe impure air.

FIGURE 14.—Grinding on an open wheel. Dust removed by a current directed downwards. The momentum acquired by the incoming air is in this case made use of for carrying the dust downwards to an exhaust opening on the floor.

FIGURE 15.—Removal of fumes by curtained hood, which is more effective than the open hood shown in Figure 16.

FIGURE 17.—Removal of dust produced by rollers. The dust is removed at the point of formation, through slots in a wedge-shaped exhaust pipe, as indicated by the arrows.

Plate I



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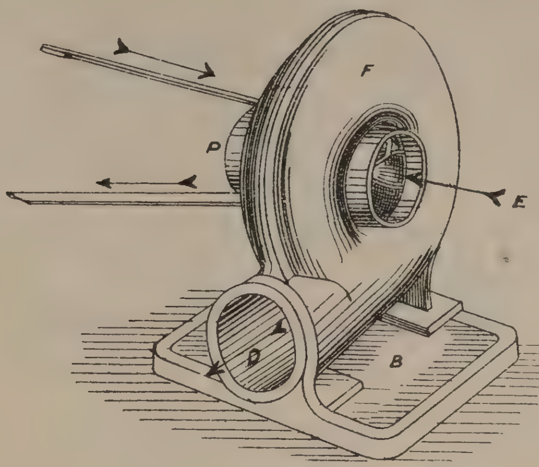

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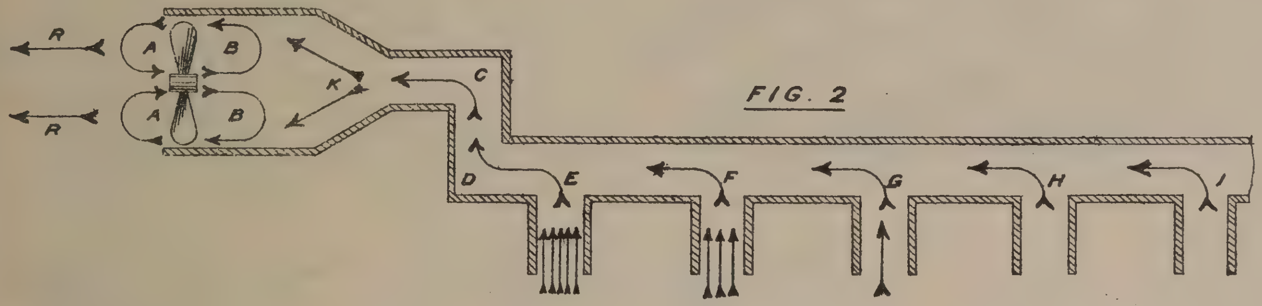
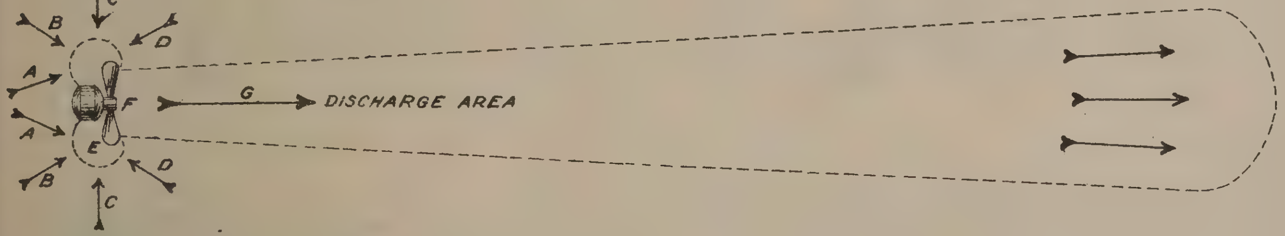


FIG. 2

FIG. 4



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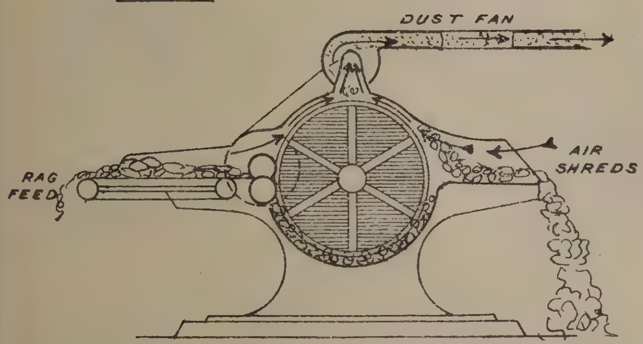

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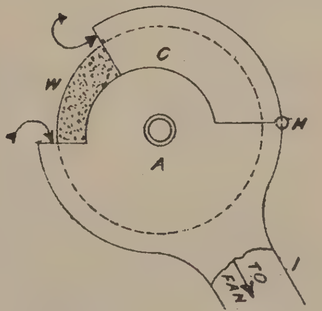

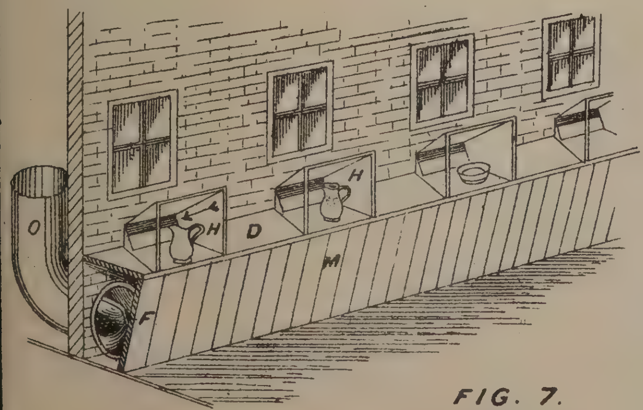

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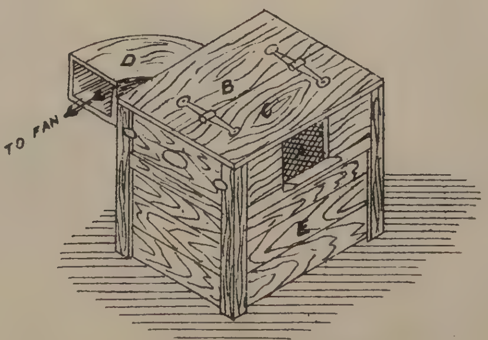

FIG. 8.

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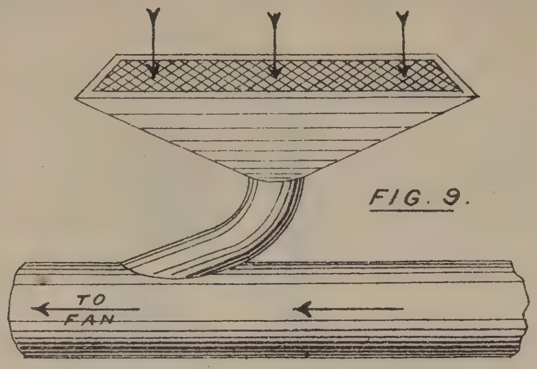
Plate II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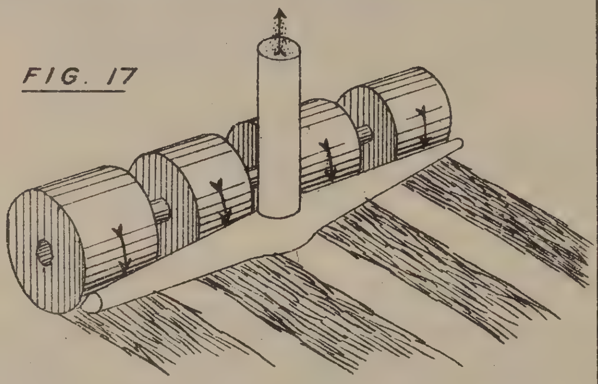
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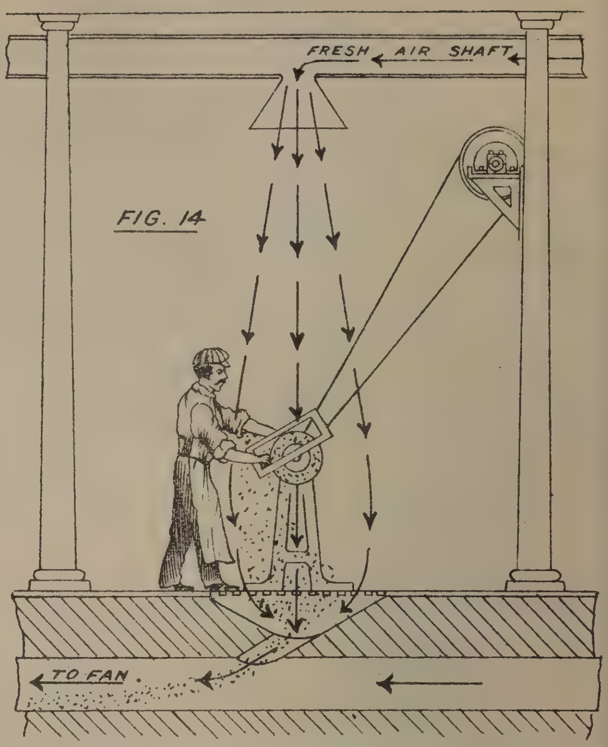
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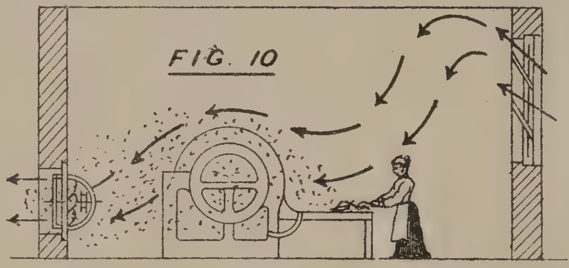
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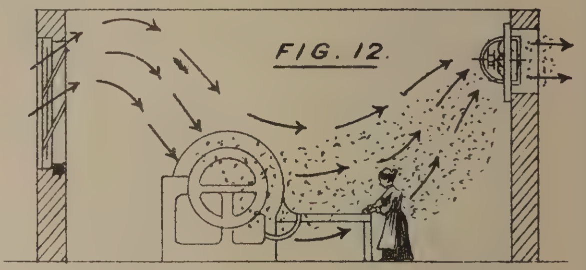
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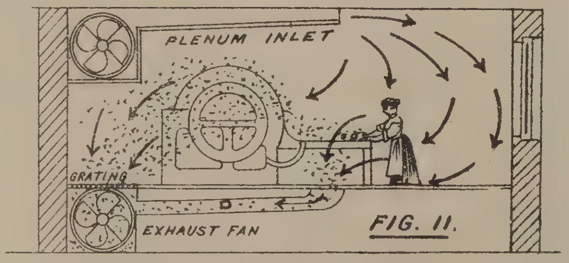
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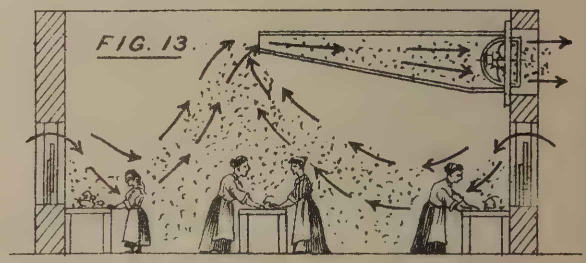
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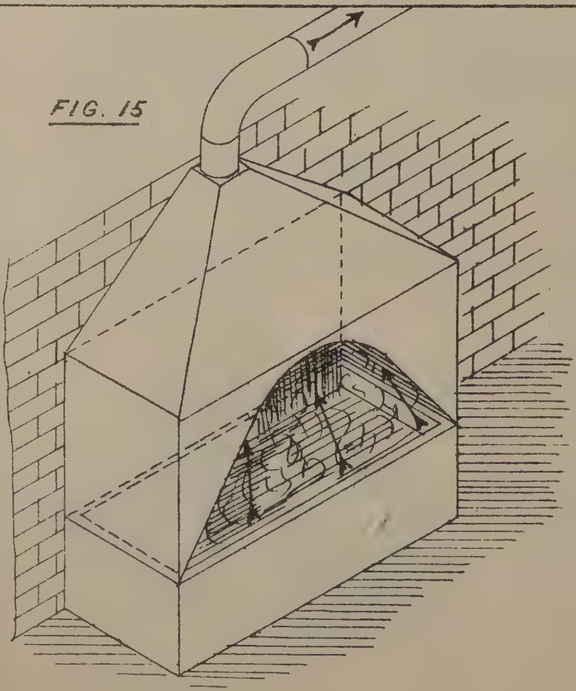
FIG. 15

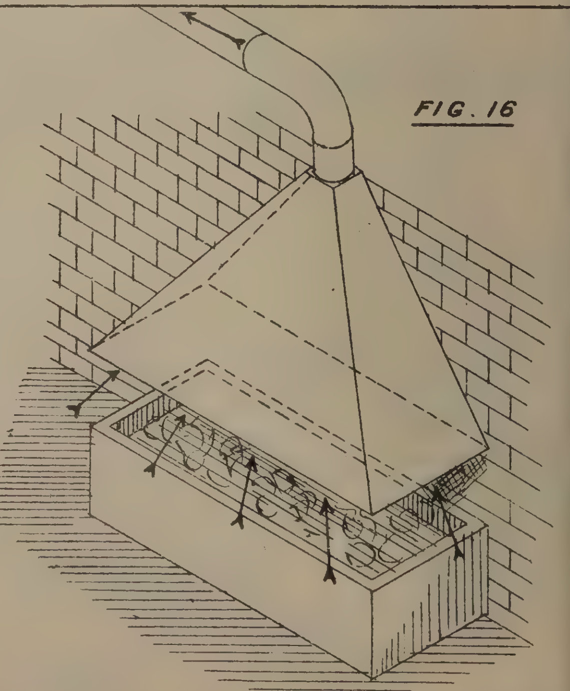
FIG. 16

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SECOND

REPORT

OF THE

DEPARTMENTAL COMMITTEE

APPOINTED TO ENQUIRE INTO THE

VENTILATION OF FACTORIES AND WORKSHOPS;

PART II.—APPENDIX.

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SECOND REPORT OF THE DEPARTMENTAL COMMITTEE APPOINTED TO INQUIRE INTO THE VENTILATION OF FACTORIES AND WORKSHOPS.

PART II.—APPENDIX.

Note.—This volume, which forms the Appendix to the Second Report of the Committee and has been prepared by the Secretary, Mr. C. R. Pendock, contains a number of plates and diagrams explaining the results of experiments carried out by the Committee and illustrating their recommendations. Explanatory notes are added to each plate.

LIST OF PLATES AND DIAGRAMS.

(*Plates I. and II. are published with the Report in Part I.*)

Section I.—Experiments on the Construction of Main Ducts and the arrangement of Throats or Branches.

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PLATE IV.—Experimental Apparatus.—Fig. 1.—Arrangement of fan, parallel duct and vertical throats with wide hoppers. Fig. 2.—Parallel duct with throats removed. Figs. 3, 4, and 5.—Sections of wide, medium and narrow hoppers.

PLATE V.—Experimental Apparatus.—Fig. 6.—Arrangement of Fan with tapered duct, slanting throats and medium hoppers. Fig. 7.—Tapered duct, vertical throats and wide hoppers. Fig. 8.—Tapered duct with throats removed.

PLATE VI.—Arrangement of Experiments.—Sectional Diagrams showing fan, main ducts, throats and hoppers as arranged for the principal tests, viz.: *Part* 1.—Fig. 9.—Vertical 4-inch throats on parallel duct. Fig. 10.—Slanting 4-inch throats on same duct. Fig. 11.—Reversed 4-inch throats on same duct. Fig. 12.—Slanting 2-inch throats on same duct. Fig. 13.—Reversed 2-inch throats on same duct. Fig. 14.—Parallel duct turned over to show plain holes and slides *a*, *b*, *c*, *d*.

Part 2.—Fig. 15.—Tapered duct with 4-inch vertical throats and wide hoppers. Fig. 16.—Tapered duct with slanting 4-inch throats and medium hoppers. Fig. 17.—Tapered duct with 4-inch vertical throats—hoppers removed. Fig. 18.—Tapered duct turned over to show plain holes and slides *a*, *b*, *c*, *d*.

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PLATE VII.—Experiments on Duct Construction.—Series 1 :—

Exhaust Currents—Tabulation of Results.

Parallel Duct with—	Tapered Duct with—
Fig. 1. 4-inch vertical throats and hoppers.	Fig. 2. 4-inch vertical throats and hoppers.
,, 3. 4-inch vertical throats and hoppers.	,, 4. 4-inch vertical throats with hoppers off.
,, 5. 4-inch slanting throats.	,, 6. 4-inch slanting throats.
,, 7. 4-inch slanting throats.	,, 8. 4-inch slanting throats.
,, 9. Large plain holes.	,, 10. Large plain holes.
,, 11. Medium plain holes.	,, 12. Medium plain holes.
,, 13. Small plain holes.	,, 14. Small plain holes.
,, 15. 4-inch slanting throats.	
,, 16. 4-inch slanting throats.	
,, 17. 4-inch slanting throats (reverse slant).	
,, 18. Same as 16, throats reverse slant.	

Experiments on Equalisation of Current.

Figs. 19, 20, 21 and 22. Parallel trunk with vertical 4-inch throat and wide hoppers.

PLATE VIIa.—Experiments on Duct Construction—Series 2 :—

Blast and Exhaust Currents—Tabulation of Results.

Exhaust Currents tested in parallel duct with—

Fig. 1. Vertical 4-inch throats and hoppers.
,, 2. Throats slanting at 30 degrees.
,, 3. 4-inch throats slanting at 30 degrees, hoppers removed.
,, 4. Same throats with end of duct wide open.
,, 5. 4-inch throats slanting at 60 degrees—end of duct closed.
,, 6. Plain holes 4 × 4 without air guides.
,, 7. Holes with pocket air guides inserted.

Blast currents tested in parallel duct with—

,, 8. 4-inch vertical throats and hoppers.
,, 9. 4-inch throats slanting at 60 degrees with hoppers.
,, 10. 4-inch throats slanting at 30 degrees with hoppers.

Exhaust currents tested in tapered duct with—

,, 11. Vertical 4-inch throats with hoppers.
,, 12. Same throats, but main duct reversed—small end towards fan.
,, 13. Small 2-inch vertical throats—duct reversed as before.
,, 14. Small 2-inch throats slanting at 30 degrees—duct reversed.

Blast currents tested in tapered duct with—

,, 15. Large plain holes.
,, 16. Vertical 4-inch throats, with end of duct open.
,, 17. Holes with pocket air guides inserted.
,, 18. Vertical 4-inch throats—end of duct closed.
,, 19. 4-inch throats slanting at 60 degrees.
,, 20. 4-inch throats slanting at 30 degrees.

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hood. Fig. 37.—Funnel-shaped hopper. Fig. 38.—Square mouthed hopper. Fig. 39.—Glazed verandah hood. Fig. 40.—Metal slipper hood. Fig. 41.—Flat nozzle. Fig. 42.—Letter-box slit. Fig. 43.—Funnel-shaped sweep hole. Fig. 44.—Tobin tube with flat filter. Fig. 45.—Tobin tube with diagonal filter. Fig. 46.—Tobin tube with dished filter. Fig. 47.—Short-circuiting in a centrifugal fan.

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SECTION I.—EXPERIMENTS ON THE CONSTRUCTION OF MAIN DUCTS AND ARRANGEMENT OF THROATS OR BRANCHES.

A large number of failures in local ventilation are due to ignorance with regard to the proper proportioning and arranging of main and branch ducts, and there is a dearth of published data, and surprising absence of knowledge in connection with a matter so important.

There appears however to be an opinion amongst the most intelligent makers, that an exhaust system of ventilation to be successful should approximate as nearly as possible to the theory expressed in Plate III, fig. 1*a*. The broad lines of this conception of a main duct may be set down as follows :—

1. A main duct should be considered as a combination of, or built up formation of all the smaller ducts which lead into it, and this should be true of the main duct at any section in its length. It should therefore be equal in sectional area (or carrying capacity) to the combined area of all its tributaries.

2. It should receive the air current from each tributary duct with the least possible disturbance of velocity and direction.

3. If properly constructed on these lines, the flow of air at each inlet or throat should have the same linear velocity as the flow at any other inlet, or at any other section of the main duct, without recourse to local throttling or empirical adjustment.

Plate III., *fig.* 1*a*, diagrammatically illustrates this conception. At the extreme right of fig. 1*a* the duct consists of one small pipe of square section equal to the inlet No. 1 and of the section shown at A. At a point nearer the fan it is joined by tributary No. 2, and the joint section becomes that shown at B, which is the equivalent of inlets 1 and 2 combined. At the next point towards the fan it is joined by tributary No. 3, and has a section C, equivalent to the inlets 1, 2 and 3, and so on, until five inlets have been accommodated by the section shown at E. Then in order that the flow of air should continue without interruption, each tributary is joined up to the main duct by a sweeping curve which connects both duct and branch tangentially.

The result of sheafing a bundle of branches together in this way is two-fold :—

First. The main duct becomes a gradually tapered one, being largest at E and smallest at A.

Secondly. The current of air from each tributary branch arrives at the junction with the main duct after having acquired a speed and direction practically coincident with that of the main stream within it.

It is demonstrated in Plate XV., however, that a duct of the shape shown at section E is wasteful of metal, with consequent extra friction, so that in practice it is found better to get as nearly as possible to a section either perfectly square or perfectly round, the latter being the better of the two. If the square form be selected for convenience the main duct will properly assume the shape shown in fig. 2*a*, with sections F, G, H, I, and J, to accommodate the inlets I., II., III., IV., and V., respectively. Such a duct would have the same capacity as the one shown above, but would have a more correct and shapely appearance, and as the form of junction shown at fig. 1*a* for each branch could not be rigidly followed in fig. 2*a*, the ideal form would be approached as nearly as possible by having a slanting intake, making an angle not greater than 30° with the main duct.

It has come, however, to be commonly considered that the real essential of success in obtaining a uniform flow of air is the tapered form of the main duct, and that, so long as the main duct is tapered the inlets can be made to enter the main duct at right angles, or almost anyhow ; and that there will still be an equal flow at each. This an error, as will be presently shown.

The investigations described below were made with a view to determining the effects of (1) tapering the main ducts, and (2) varying the inclination of branch ducts to main duct, on the relative amounts of air entering or leaving each branch duct. The experiments were designed by the Secretary, and carried out at the works of Messrs. W. Gardner & Sons, Limited, Engineers, Gloucester, who had very kindly placed their test-house at the Committee's disposal, together with the necessary woodwork, apparatus, and driving power. The actual tests were made by Dr. Haldane assisted by the Secretary and the Manager of the works.

Apparatus Employed.

Fan.—The fan used was an ordinary mill fan of the centrifugal paddle wheel type, such as is used for exhausting dust from millstones, &c., in flour mills. The fan wheel consisted of four arms, each carrying a vane or blade 4 inches by 8 inches, the diameter from tip to tip being 16 inches. The speed of the fan wheel was about 910 revolutions per minute, but varied somewhat in different series of experiments, so that the total volumes of air passing along the main duct with different arrangements of branch ducts cannot and were not intended to be compared.

Inlets to fan.—On each side of the fan casing there was a central opening to serve as an inlet to the fan, and these were connected by two metal ports to the real inlets beneath the base plate of the fan (*see* fan section, Plate VI., fig. 9).

Outlet from fan.—The discharge opening V was 8 inches wide by 9 inches high, and from this the air was blown out horizontally, and at right angles to the main duct.

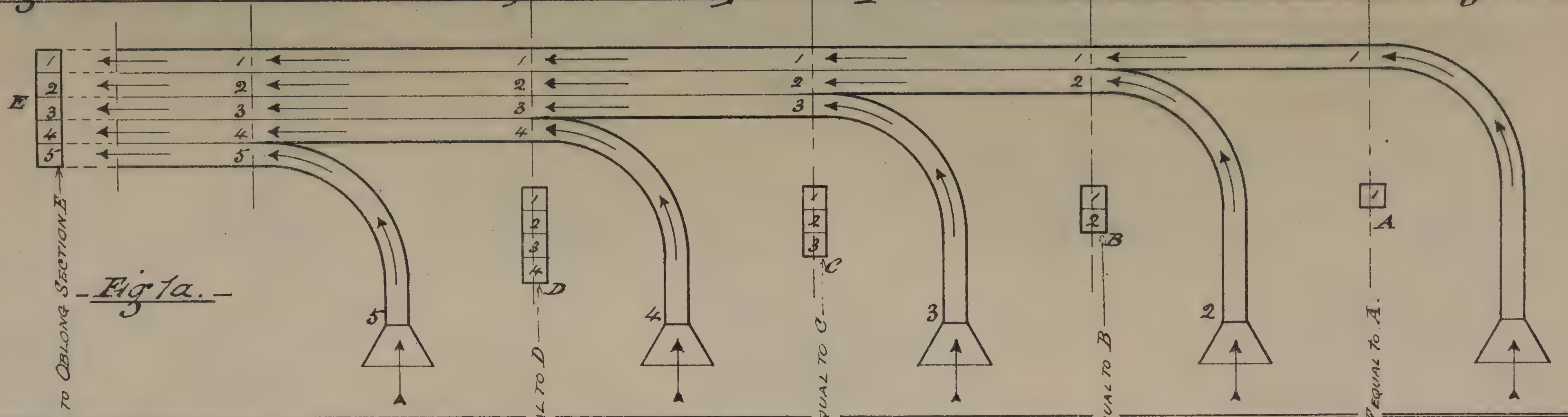
When the fan was used for exhausting, its inlets were connected with the main duct as in Plate VI. When it was used for blowing, the main duct was connected with its outlet by a junction piece bending round at right angles.

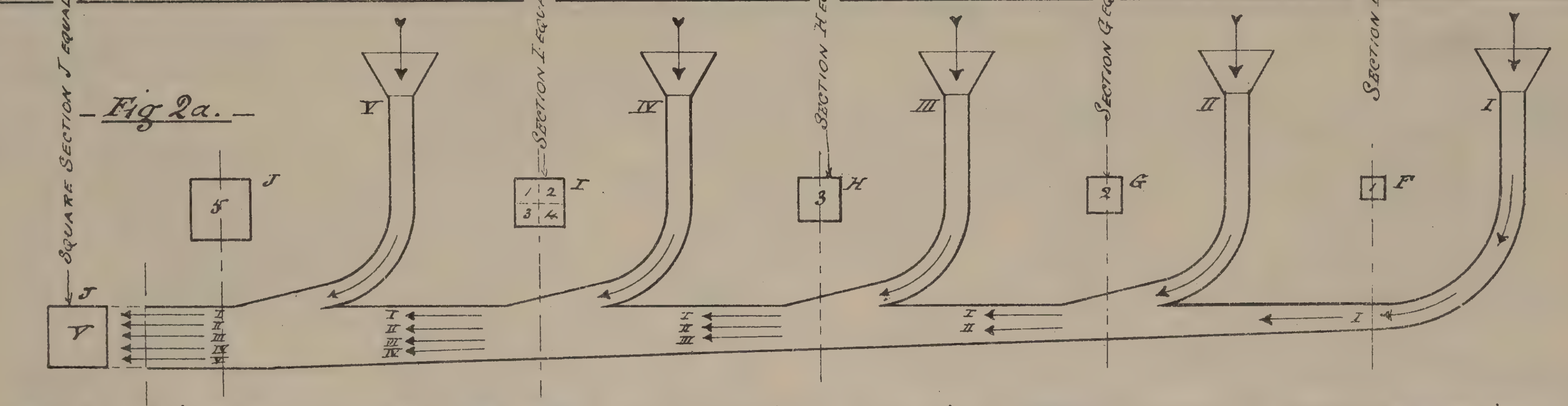
Motive power.—The fan pulley (P) was driven at a speed of about 910 revolutions by a 3-inch belt, deriving its power from a 42 b.h.p. gas engine, which also did the ordinary work of the adjoining shop. The centre of the fan case was about 2 feet 6 inches from the centre of the nearest hopper or throat.

Main ducts.—Of these there were two, each about 12 feet in length. One was a parallel-sided trunk of square section, measuring 8 inches each way on the inside (*see* Plates IV. and VI., figs. 9 to 14). The right-hand extremity of the trunk was bolted beneath the fan in such a way that the openings S and H coincided in position with the ports G and H beneath and on each side the fan. To facilitate the flow of air at the dead end of the trunk a curved plate (E) was placed to deflect the air into port H (*see* fan section, fig. 9). The other extremity of the trunk was closed by a cover N. On the top of the trunk oblong openings (each 7½ inches by 4 inches) were cut at a distance of 3 feet apart, and through these the air passing through each throat joined the main stream. A zinc shutter was fitted to slide over each opening for purposes of adjustment (*see a*, *b*, *c*, and *d*). The other main trunk was made to taper away from the fan, the internal section under the throat D being 8 inches square, and under throat A 4 inches square (*see* Plates V. and VI., figs. 15 to 18). In other respects the tapered duct was constructed and fitted similarly to the parallel-sided trunk, the wood used in constructing the former, however, being just 25 per cent. less in quantity than in the latter.

Throats.—Three sets of throats or branch inlets were employed. Each set was made to fit on either main duct, and any one was interchangeable with any other. Each throat in the vertical set was about 15 inches high, and had an internal section of 4 inches square or 16 square inches. It will thus be seen that the parallel-sided duct, which had a capacity of 8 inches by 8 inches or 64 square inches, was uniformly equal to the combined areas of all four throats, or 4 inches by 16 inches = 64 square inches. In the tapered trunk the sectional area below each throat was equivalent to the number of throats it had to accommodate and

— Fig: 1a — Theoretical Construction of Main Duct: formed by Individual Branch Ducts sheaved together. —





— Fig 2a. Diagram showing how the Above Construction is most nearly Approximated in Modern Practice. —

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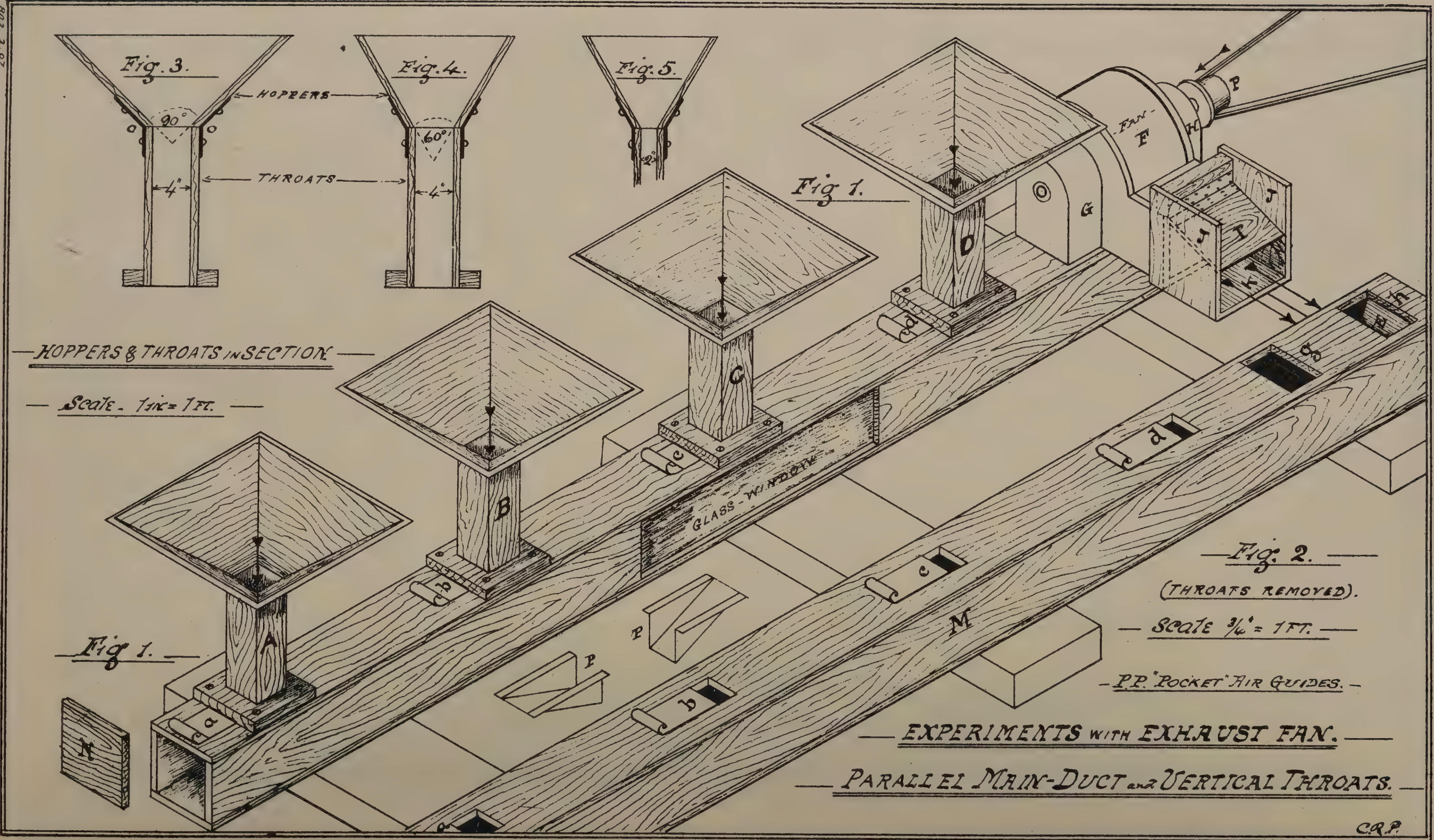
— Plate IV. —



— HOPPERS & THROATS IN SECTION —

— Scale – 1 in = 1 FT. —

— Fig. 2. —

(THROATS REMOVED).

— Scale ¾" = 1 FT. —

— P.P. "POCKET" AIR GUIDES. —

— EXPERIMENTS WITH EXHAUST FAN. —

— PARALLEL MAIN-DUCT and VERTICAL THROATS. —

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PLATE V.

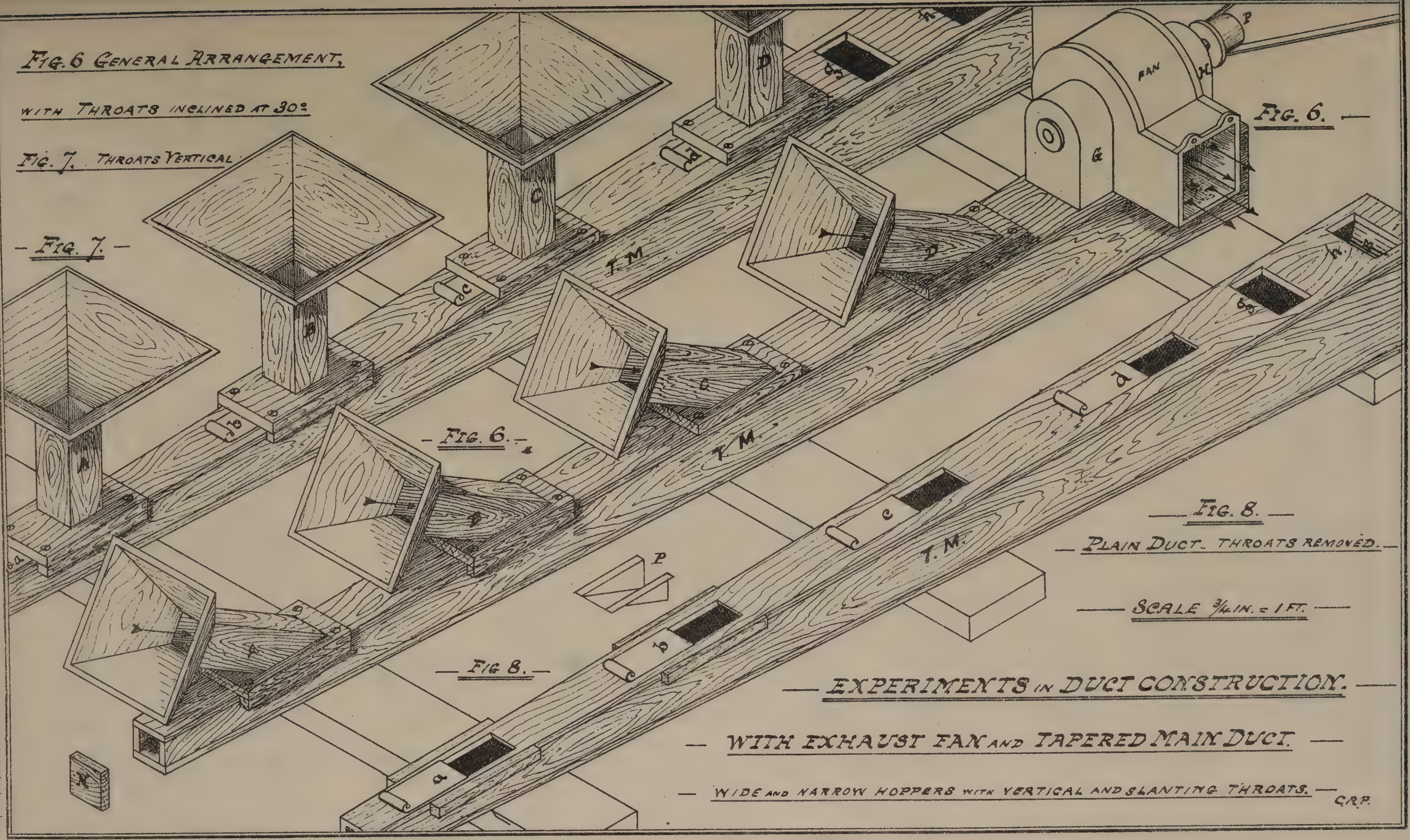

FIG. 6 GENERAL ARRANGEMENT,

WITH THROATS INCLINED AT 30°

FIG. 7. THROATS VERTICAL.

— FIG. 8. —

— PLAIN DUCT – THROATS REMOVED. —

— SCALE ¾ IN. = 1 FT. —

— EXPERIMENTS IN DUCT CONSTRUCTION. —

— WITH EXHAUST FAN AND TAPERED MAIN DUCT. —

— WIDE AND NARROW HOPPERS WITH VERTICAL AND SLANTING THROATS. —

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— EXPERIMENTS ON DUCT CONSTRUCTION WITH EXHAUST FAN. —

SECTIONAL DIAGRAMS SHOWING PRINCIPAL ARRANGEMENTS TESTED.

— PART 1. WITH PARALLEL MAIN DUCT. —

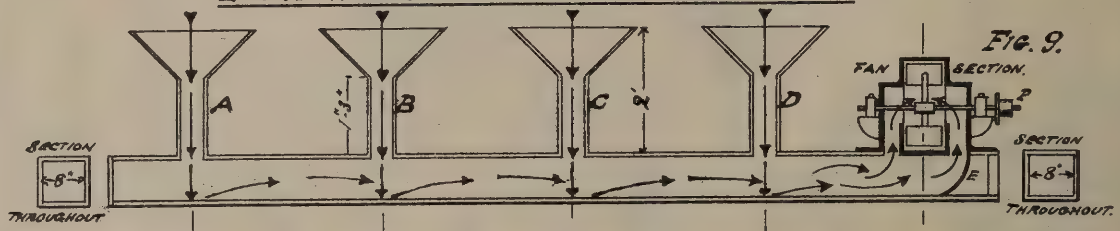

FIG. 9.

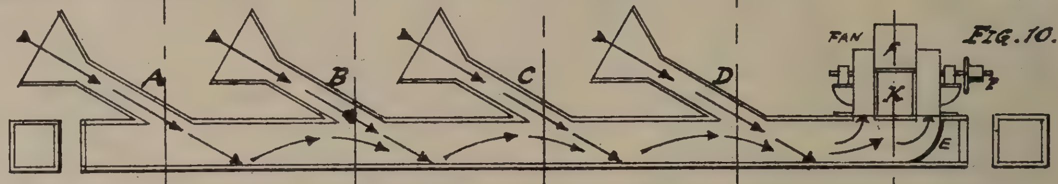

FIG. 10.

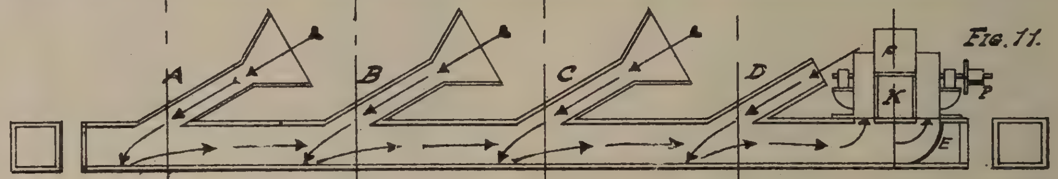

FIG. 11.

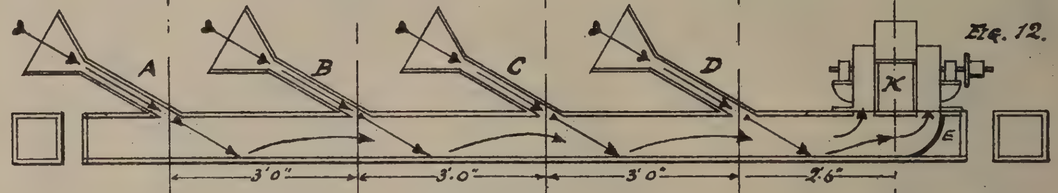

FIG. 12.

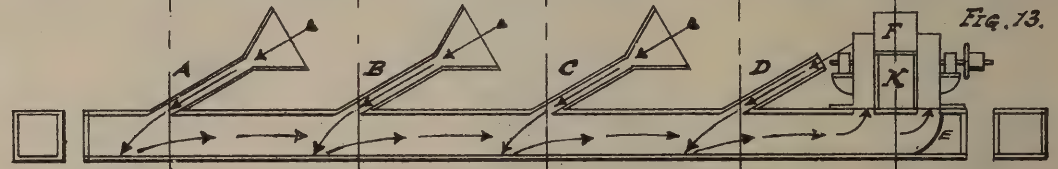

FIG. 13.

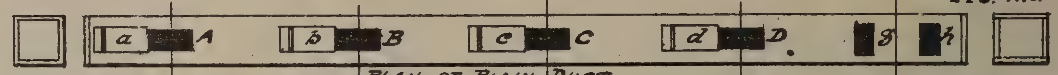

FIG. 14.

PLAN OF PLAIN DUCT

— PART 2. WITH TAPERED MAIN DUCT. —

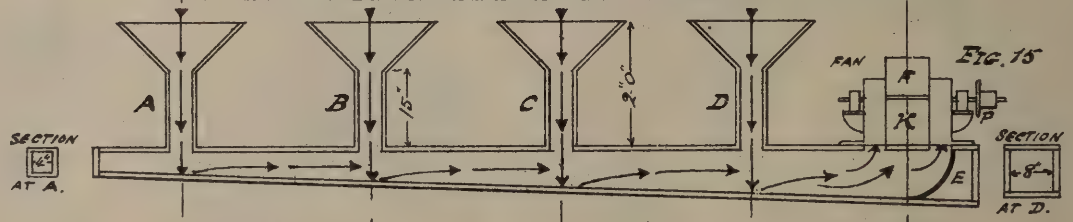

FIG. 15

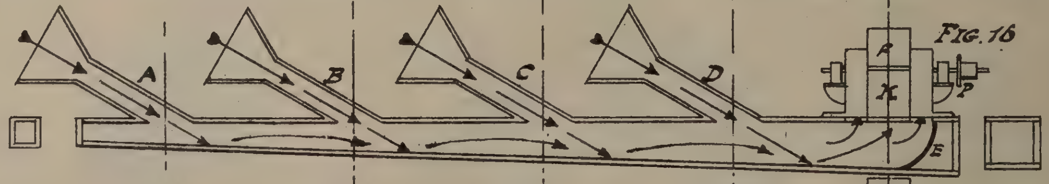

FIG. 16

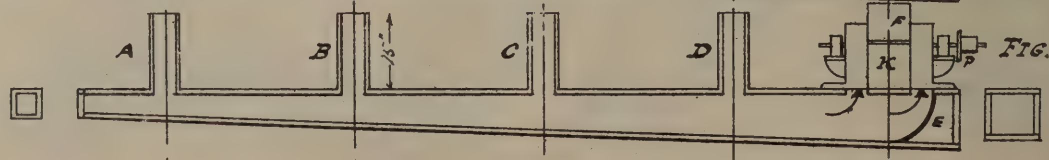

FIG. 17.

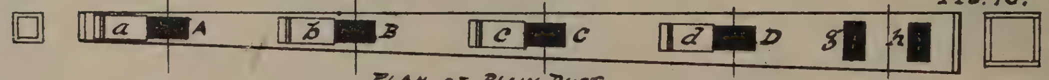

FIG. 18.

PLAN OF PLAIN DUCT

(SCALE THROUGHOUT. ½ IN = 1 FT.)

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no more; thus, under throat A (fig. 6, Plate V.) the section was 16 square inches, or exactly equal to the throat. At D it was 64 square inches, or exactly equal to the four throats. Similarly, at B and C it would be equal to two and three throats respectively.

The next set of throats were of the same section, but were inclined to the main trunk at an angle of 30°, their length being much the same on the under side as the vertical ones.

The third set of throats were inclined at the same angle of 30°, but had an internal section of only 4 square inches (2 inches by 2 inches). These were, therefore, disproportionately small to the main trunk, the sectional area of each being one-sixteenth that of the main duct instead of one-fourth as in the former cases. One series of observations was also made with throats inclined at 60°.

Hoppers.—Hoppers or air guides were fitted on the throats as shown in Plate VI., bnt their action was not investigated and was probably very slight.

Explanation of Plate VI.—The figures on this plate give the sectional form and dimensions of the trunks and various fittings, each successive view being a different arrangement of the parts employed. The reference letters on each throat are those employed in Col. 3 of Plate VII. The fan F is shown in section on fig. 9, so that the inlets to fan-wheel can be more clearly seen. The arrows in figs. 9, 10, 15, and 16 roughly indicate the movements of coarse particles of dust, as observed through a glass pane.

Explanation of Chart (Plate VII.).—The horizontal columns represent by their length* the linear velocity as tested at each branch inlet In making these tests the same $2\frac{3}{4}$-inch anemometer was placed successively at exactly corresponding points in each opening. The figures given represent, therefore, the relative air velocities at the different openings, but not necessarily the mean absolute velocities through the whole cross section of each opening. The dot and dash line at right angles across the ends of horizontal columns represents the average linear velocity for all the throats for that particular trial. The dash-dotted line shows the average volume of air passed through each throat. The scale used for velocities is 1 inch = 500 feet, whereas that used for volumes is 1 inch = 300 cubic feet. The pin-dotted line indicates the approximate total volume of air passed through all four throats to the fan. The position and size of the throats under each test are sketched in Col. 2, and the reference letter for each is given in Col. 3. A similar description applies to Plate VIIA., in which, however, certain details as to volume are omitted.

Results of the Experiments.

The results are shown graphically on Plates VII. and VIIA., and may be summarised as follows :—

A.—Exhaust Ducts.—Plate VII.

1. *Parallel-sided* v. *tapered main exhaust ducts.*—On comparing the corresponding members of each pair in experiments 1 to 14, Plate VII., it will be seen that the effect of substituting a tapered for a uniform parallel-sided main duct was always to exaggerate the difference in air-flow through the different branch ducts or openings. For example, the currents through ducts A and D were as 1 to $1\frac{1}{2}$ with the uniform air-duct, but as 1 to 2 with the tapering air-duct. A main exhaust air-duct tapering towards the far end is thus not merely of no use in helping to equalise the flow through the branch air-ducts, but its influence, if any, is distinctly harmful, as might, indeed, have been predicted on purely theoretical grounds.

---

* The results of each test are also given in plain figures on each column so as to show precisely what this column represents.

2. *Influence of slant of branch ducts.*—It will be seen that with branch ducts at right angles to the main duct, or with simple openings in the latter, the currents through the branch duct or opening are greater or less according as each branch or opening is nearer or further from the fan. When, however, the branch ducts are sloped at an angle of 30° towards the direction of the air current in the main ducts, the air-flow through the various branches is approximately equal, as shown in Nos. 5 to 8, 15 and 16. When the branch ducts are slanted at an angle of 30° against the direction of the air current in the main duct the inequality in air-flow along the different branch ducts is greater than when they are placed at right angles to the main duct (compare Nos. 3 and 17). Simple pocket air-guides of the form shown in Plates IV. and V., and Plate VIIa. (No. 7) were not so effective in producing equality as branch ducts at an angle of 30°.

3. *Influence of size of branch ducts or openings.*—On comparing Nos. 9, 11, and 13, Nos. 10, 12, and 14, or Nos. 17 and 18, it will be seen that the larger are the openings in the main ducts, or the branch air-ducts (unless they are sufficiently slanted), the greater is the tendency towards inequality in the air-flow through these openings or branch air-ducts. Thus with openings 8 inches by 4 inches into a tapering main duct the currents through A and D were as 1 to 11, while with openings 3 inches by 3 inches they were as 1 to $1\frac{1}{3}$.

Remarks.—It is evident from the above results that approximate equality of flow through each of a series of branch exhaust ducts or openings may be obtained in several ways.

One method is to make the combined cross-sections of the branches or openings considerably less than that of the main duct. By this means approximate, but not complete, equality may be obtained, even if the cross-sections of the ducts or openings are all equal. The disadvantage of this method is that the resistance is thereby greatly increased, and the total flow of air correspondingly diminished, particularly with a propeller fan, as explained in the text of the Memorandum.

Another method is to diminish the size of the openings as the fan is approached. This has to be done empirically, and is a troublesome process. Nos. 19 to 22, Plate VII., give the results in the case of the 4 inches by 4 inches openings in one of the experimental ducts. By this process, also, the resistance is increased, unless the far openings are increased in size so as to compensate for the diminution in size of the near ones.

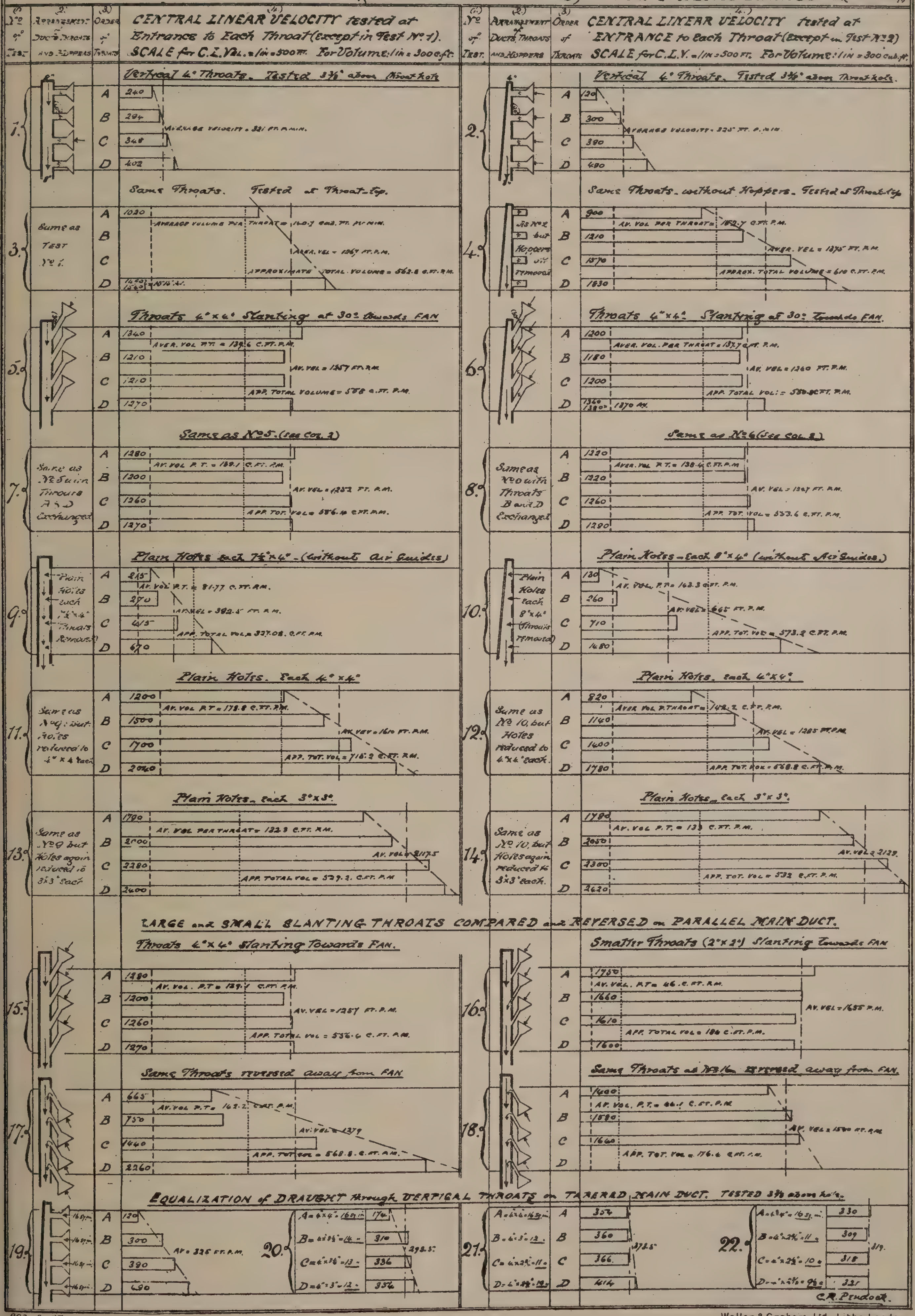
A third possible method does not seem to have ever been tried in actual practice. It is to make the exhaust duct taper *towards* the fan, instead of away from it, in accordance with the common mistaken practice. If the tapered end of the main duct were not smaller than the fan opening this method might give satisfactory results in some cases, but would usually be very inconvenient. In one of the experiments actually tried with a duct tapering in this way the flow through the branch ducts was very unequal on account of the tapered end being much too narrow, its cross section being only a fourth of the combined cross sections of the branch ducts (Plate VIIa., No. 12).

The fourth and best method is to make the branch ducts enter the main duct with a good slant in the direction of the current in the main duct. This method is not merely easy to carry out, but it lessens the resistance, and with a propeller fan would considerably increase the air-flow. The energy communicated to the air in its passage through the branch ducts is not lost, as when these ducts are at right angles to the main ducts. One consequence of this is that the total resistance is less, and another is that the pressure is the same all along the main duct and does not diminish towards the fan end. Such diminution of pressure must necessarily occur (apart altogether from skin friction) when the ducts are at right angles, since velocity in the direction of flow in the main duct is being communicated to a fresh portion of air at the junction of each branch duct.

PLATE VII

EXPERIMENTS IN DUCT CONSTRUCTION PARALLEL AND TAPERED DUCTS COMPARED.

WITH PARALLEL MAIN DUCT (8 in sq.) (ANEMOMETER TESTS) WITH TAPERED MAIN DUCT. (8 in to 4 in sq.)



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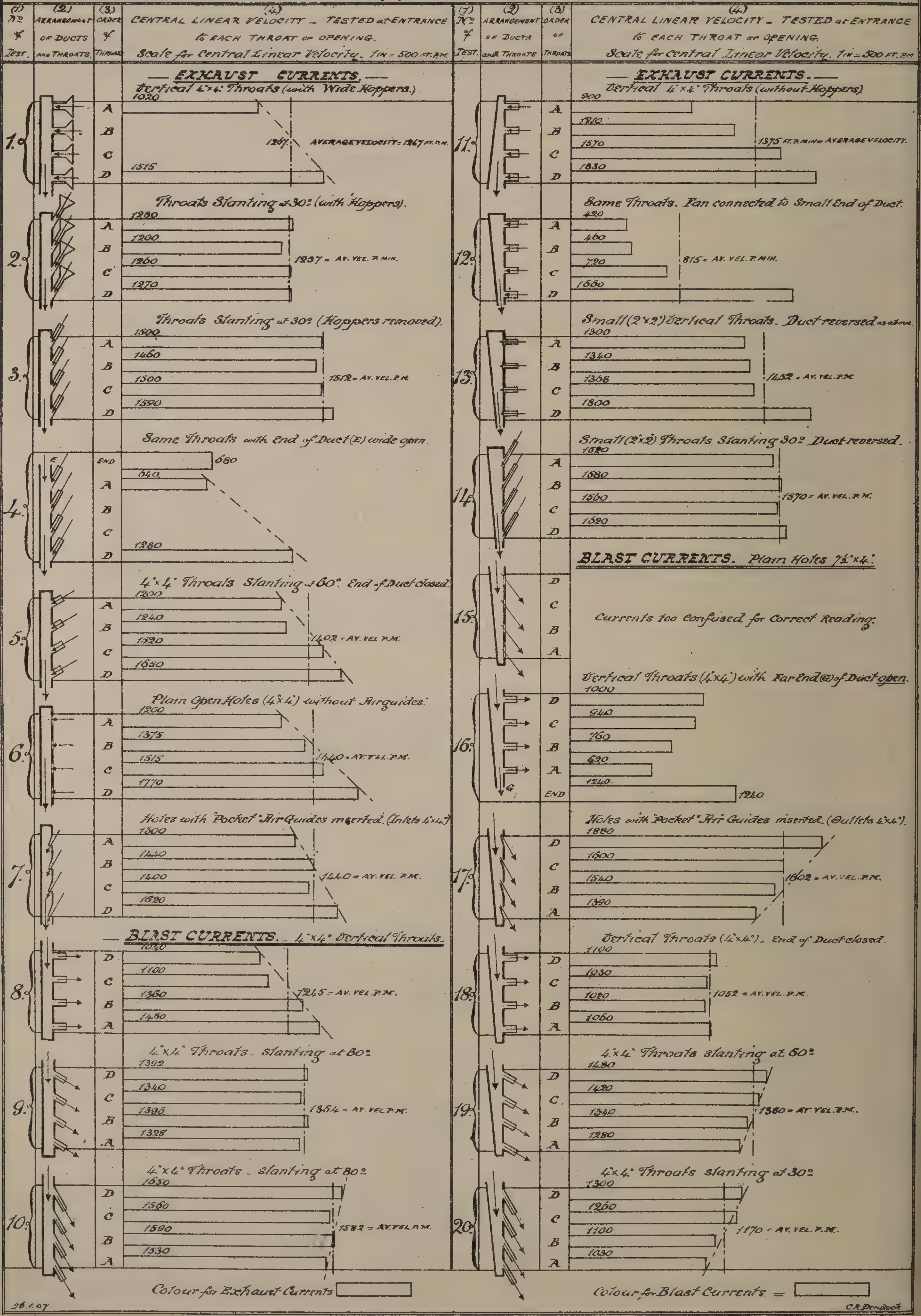
EXPERIMENTS IN DUCT CONSTRUCTION (CONTD). BLAST AND EXHAUST CURRENT COMPARED.

WITH PARALLEL MAIN DUCT 8IN. SQ. (ANEMOMETER TESTS). WITH TAPERED MAIN DUCT. 8" TO 4" SQ.



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B.—INLET DUCTS.—PLATE VIIA.

1. *Parallel-sided* v. *tapered inlet ducts* (*Plate VIIA.*)—On comparing No. 1 with No. 8 it will be seen that with uniform parallel-sided ducts and branch ducts at right angles to it the air-flow through the branch ducts was unequal, whether the air was exhausted or blown in, but that whereas with exhaust currents the branch duct nearest the fan passed the largest amount of air, it was the branch furthest from the fan which passed most air when the fan was blowing in. This latter result is perhaps at first sight surprising, but is exactly what was to be expected on theoretical grounds, since the velocity of the air in the main duct was more and more checked at each successive opening, with the result that an increasing lateral pressure was produced towards the far end of the duct, the conditions in this respect being the converse of those in an exhaust duct. It should be borne in mind, however, that with long distances between the branch ducts skin friction in the main duct may neutralise, or more than neutralise, the effect just described.

On comparing No. 11 with No. 18 it will be seen that whereas the tapering of an exhaust main duct away from the fan *increased* the inequality in air-delivery through ducts at right angles to it, the converse was the case with an inlet main duct, so that by tapering the main inlet the delivery through the branch ducts was *equalised*. The explanation of this fact will be evident from what has already been said.

2. *Influence of slant on main ducts.*—On comparing Nos. 8, 9 and 10 it will be seen that, as in the case of exhaust ducts, slanting the branch ducts compensates, or even slightly over-compensates, the inequality in air-flow through them, provided the main duct is of uniform cross-section. At the same time the total air-delivery is increased owing to loss of energy being avoided, so that this arrangement is very advantageous. With a tapered main inlet duct and slanting branch ducts, the flow through the branch ducts becomes uneven, as shown in Nos. 18, 19, 20.

3. *End of main duct open.*—If the end of an inlet duct be open, as in No. 16, the air escapes through the opening with a much higher velocity than through branch ducts. In the case of an exhaust main duct, on the other hand, this marked result is not produced, since a given diminution of pressure at any point of junction in an exhaust duct causes air to flow equally along both branches, whatever their direction, unless the resistances in them are unequal.

PLATE VIII.

EXPERIMENTS WITH PROPELLER FAN.—DIAGRAM OF RESULTS.

(Diagram and Sketches drawn by the Secretary.)

Fig. 19.—This diagram has been prepared and drawn to scale from actual observations by Dr. Haldane. The white figure indicates a longitudinal section of the area within which there was a draught exceeding 2 feet per second as measured by an anemometer, the direction of the current being indicated by arrows. It is interesting, as showing the extent to which an electric or other open fan makes its effect felt in the shape of draughts, both on the intake or suction side and in the line of blast or discharge. The white arrows " A, B, C, D," show the direction in which air was drawn towards the blades, and the area resembling the wings of a butterfly on the left of fan shows the limited region in which draughts were produced by suction. A curious feature to be specially noted is the ingathering of air around the *tips* of the blades, even to a point actually on the *discharge* side of the fan, showing the necessity of giving as much freedom of access as possible to the tips of the fan blades.

Comparison of these figures or areas on each side of the fan at once makes it apparent that the main *blast* current takes a straight, simple and sharply defined forward course through a longitudinal space concentric with the axis, whilst the *suction* or exhaust currents, on the other hand, envelop the fan in radial streams that present a much more complex formation and have a greatly restricted influence ; that is to say, their power to rapidly remove suspended dust is confined to a small radial distance from the fan centre.

The *suction* currents are, therefore, far less capable of being directed than *blast* currents, assuming both are to be used in the open without tubes : and a proper understanding of this fact may lead to a more frequent use of the latter in certain cases of dust removal—either alone or in conjunction with an exhaust (*see* instances on Plates XXI, XXXII and XLIIA.).

Fig. 20 on this plate shows a trumpet-shaped opening for the ingathering of air currents. It will be seen that air is first guided into the opening by means of a wide bellmouth O, which would cover the area from which dust or fumes required to be exhausted. But such a wide collector as this would scarcely help to increase the volume of air sucked in by the fan, whereas the very gradual constriction of the actual inlet from R to Q would do so, it having been found that a very gradually tapered intake is best for this purpose.

Fig. 21 shows a hopper with a throat of the usual construction which is generally too upright and insufficiently curved to get the best effects. A throat of more suitable curvature and inclination is shown in Fig. 9, Plate II.

Fig. 20. Trumpet-shaped Opening.

with Bell-Mouth. O

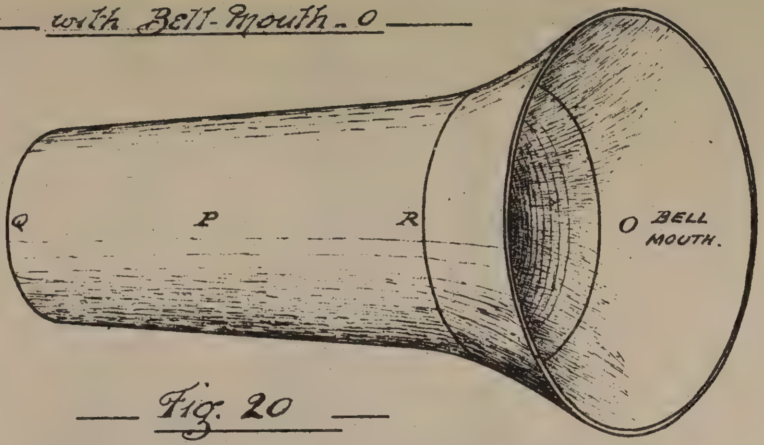

Fig. 20

Fig. 21. Hopper for Sorting Benches, etc.

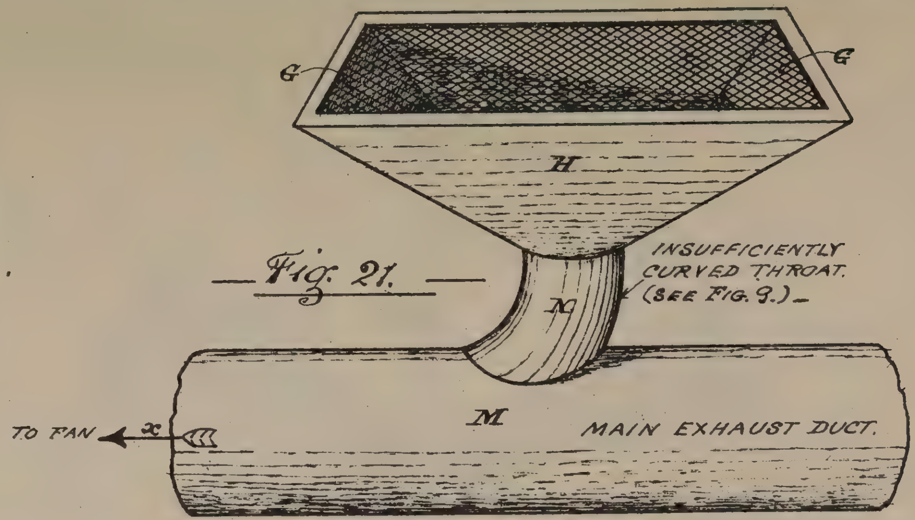

Fig. 21.

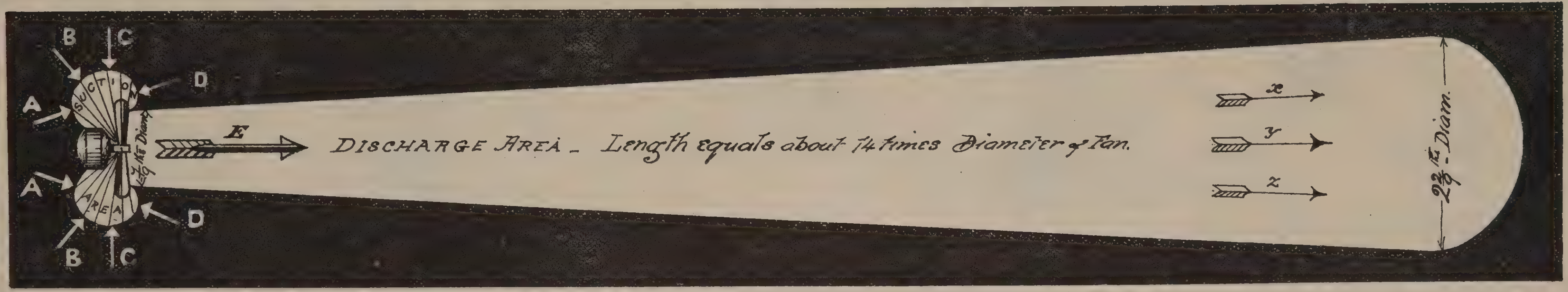
B
C
D
A
SUCTION
AREA
A
D
B
C
1 7/12 ft Diam.
E
DISCHARGE AREA - Length equals about 14 times Diameter of Fan.
x
y
z
2 9/12 ft - Diam.

Fig. 19. Diagram showing Effect of an Electric Fan. Suction and Discharge Areas drawn to scale from Actual Observations

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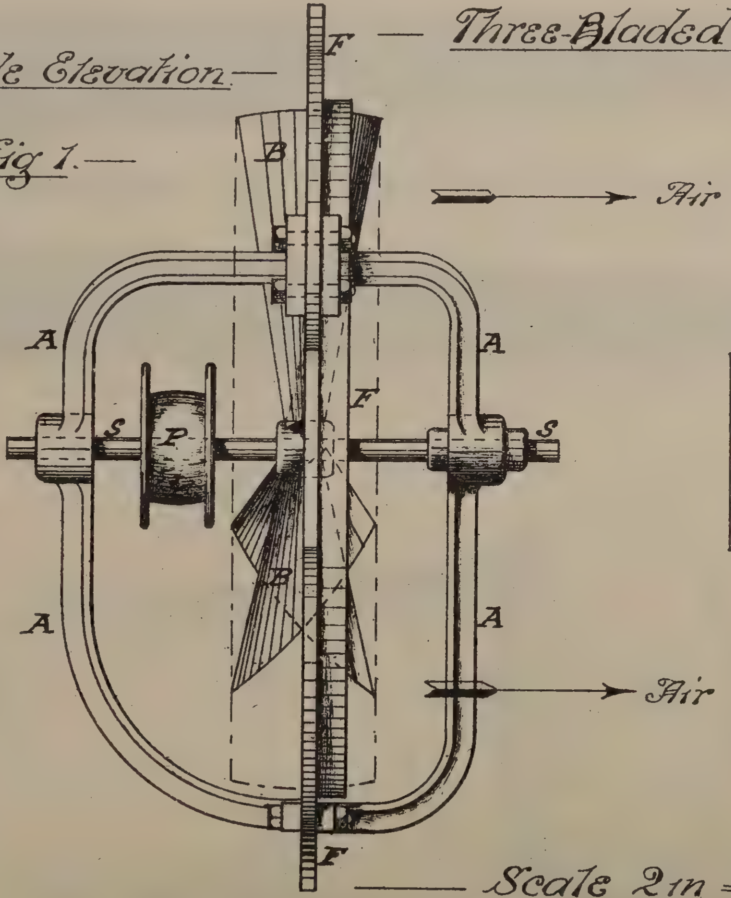
Propeller Ventilating Fans.

Three-Bladed 24-in. Fan.

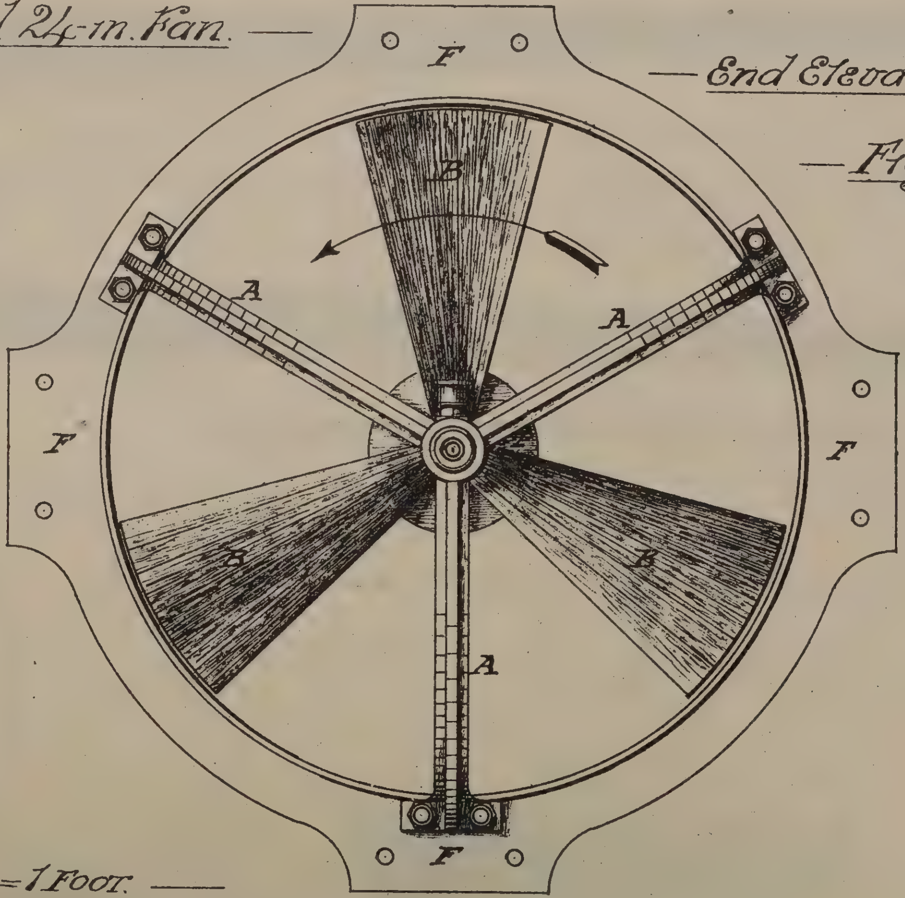
Side Elevation.

Fig 1.



End Elevation

Fig 2.



Scale 2 in = 1 Foot.

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SECTION II.—ILLUSTRATIONS OF LOCAL VENTILATION AND DUST REMOVAL.

PLATE IX.

PROPELLER VENTILATING FANS.

The fan here shown is a three bladed propeller or helical fan of a simple, ordinary type, and is of the kind described by Mr. W. G. Walker in his paper entitled "Experiments upon Propeller Ventilating Fans" (Proceedings of the Institution of Mechanical Engineers, November, 1897). In Figure 1 it will be seen that the direction of air current as indicated by the arrows is in the same line as the spindle "S" or axle of the fan; this is because, in the case of propeller fans, the blades or vanes "B. B. B." are arranged to send out a current of air at right angles to their plane of rotation. Hence, when looking at the fan as shown in Figure 2 with the blades revolving in the direction of the arrow the air moved by the vanes would be blown towards the face of the observer. It will be noticed that the frame-work is as light and open as possible, so as to give the greatest possible freedom of motion to the incoming and outgoing air, a most important condition if the propeller fan must work at its best. In this respect it differs materially from the centrifugal or pressure fan, which is enclosed in a metal casing.

It is perhaps convenient to consider air discharged from a *propeller* fan in the light of a projectile bearing some resemblance to a bullet driven straight from a gun (*see* the illustration on Plate VIII., Fig. 19). Such a projectile will travel a great distance if allowed to pursue a definite and unobstructed course, but if sent through a tortuous tube, or otherwise subjected to hindering deviations, it will rapidly lose its momentum and fail in its progress. It cannot be considered, as it too often appears to be, as a fluid forced under pressure to find its way for long distances through difficult passages, finally to emerge with almost unabated force like water from a fireman's hose. This has to be carefully borne in mind when using a propeller fan with any system of ducts, shafts, or air guides, whether for exhausting or propelling air in any required direction (*see* remarks on ducts, &c., Plate X).

It should here be mentioned that the only reliable test of the amount of air delivered by a fan is afforded by the readings of an accurate anemometer; to read the speed of a fan as a test of the air delivered may be very misleading, because, although the fan is arranged by the ventilating engineer to move a certain volume of air at a given speed, circumstances such as blocking of the ducts may seriously retard the flow of air without in the least decreasing the speed of the fan's rotation, especially when the fan is belt-driven from a source of power relatively much greater than the actual requirements of the fan.

PLATE X.

PROPELLER FANS AND BADLY ARRANGED DUCTS.

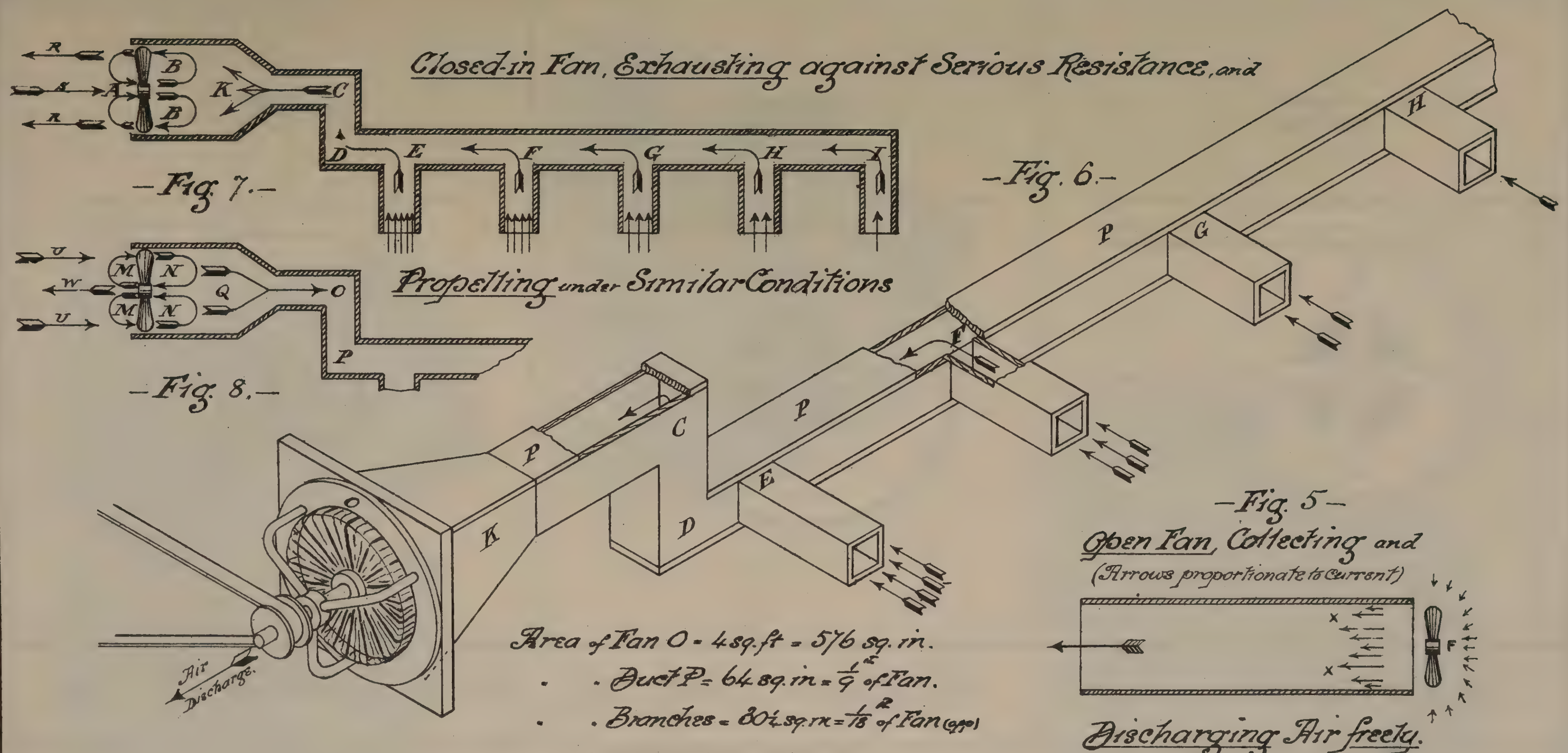
(*Diagrams drawn by the Secretary from sketches by Dr. Haldane: Fig. 5 from illustration of a paper read by Mr. W. G. Walker at the Institution of Mechanical Engineers*).

In Figure 5 the diagram shows how an open propeller fan derives its air on the inlet side and drives it through a perfectly straight tube slightly larger than its own diameter. The small arrows at X X are intended to show proportionately the velocity given to the air at various points in the tube, the velocity being at a maximum in a ring corresponding to the middle traverse of each blade, and much weaker towards the centre and periphery of the fan. This disposition of the current will help to explain what follows when the inflow or outflow of air is impeded, as in Figures 6, 7 and 8. In the latter case the fan is shown to be placed at the end of a duct which is abruptly reduced immediately behind the fan to about one-third of its diameter, and beyond that point contains a number of right angles which seriously impede the flow of air. The reduction in area at K from 576 square inches to 64 square inches will alone reduce the effect of the fan to one-ninth of its capacity, so that in its endeavour to extract nine times the amount of air that can be admitted through C the fan will set up a partial vacuum at K. This will cause the pressure on the exhaust side of the fan to be less than on the discharge side, and air from the outside will be forced back through the middle of the fan where the blades are narrowest and move slowest, and have therefore much less propelling power than at the tips. So long as the unequal pressure thus set up is unrelieved the air will be continually short-circuiting in and out of the fan, as shown by the curved arrows A and B B, whilst the conflicting efforts of the fan will be as represented by the positive arrows R R and the negative arrow S.

When the fan is set to blow *into* a duct or tube instead of drawing *from it*, an opposite effect will be produced (as shown in Fig. 8). It will be observed that in Figs. 7 and 8 the fan is placed inside the enlarged end of the duct and not just outside as in the case of Fig. 5.

The duct shown in Fig. 6 is very badly constructed for other reasons than those shown, the main shaft being of the same sectional area or capacity throughout its length and having branches E, F, G and H, each of an area nearly equal to that of the main duct, and all placed at *right angles thereto.* The result of this mistaken arrangement is that no matter what the exhausting power of the fan at D the openings at E and F will supply nearly all the air, and the remote branches H and I will scarcely supply any. (*See* experiments on Plate VIII., Figs. 1, 2, 3 and 4.) In cases where it is necessary to exhaust a series of machines or work benches at a greater or less distance from the fan the effect produced would therefore be most unequal, the exhaust current being at the near openings too powerful, and at remote openings too weak to be of value. This difficulty can be overcome by reducing the inlet area of the nearest branch and graduating all the others to a maximum at the farthest one. A much neater and more satisfactory way, however, is to make the combined sectional area of the branches equal to that of the main duct, and slant each branch duct (or throat) towards the fan at an angle not exceeding 30 degrees with the main duct. (*See* Plate V.). The draught at each opening will then be found uniform without further artificial equalisation.

When air is forced to enter a main duct through branches at right angles such as E, F, G, H and I, Figs. 6 and 7, its momentum is destroyed at each rectangular bend, and this is precisely what has to be avoided, especially where propeller fans are used. (*See* remarks on propeller fans, Plate IX.) This difficulty is overcome by giving every branch duct a curved "lead" or entry with a tangential send off, so that at the junction of each tributary air-current with the main stream the former will have already acquired a movement in the same direction as the latter. (*See* Appendix I., Plate III.)



Closed-in Fan, Exhausting against Serious Resistance, and

— Fig. 7. —

Propelling under Similar Conditions

— Fig. 8. —

— Fig. 6. —

Area of Fan O = 4 sq. ft = 576 sq. in.
" " Duct P = 64 sq. in = $\frac{1}{9}$ of Fan.
" " Branches = 80¼ sq. in = $\frac{1}{18}$ of Fan (app)

— Fig. 5 —

Open Fan, Collecting and
(Arrows proportionate to Current)

Discharging Air freely.

— Propeller Fans and Badly-arranged Ducts. —

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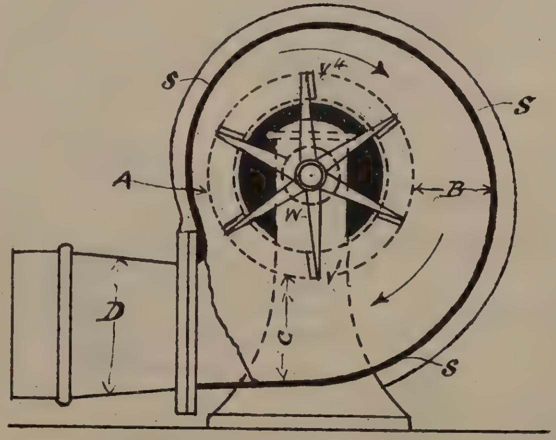
PLATE XI.

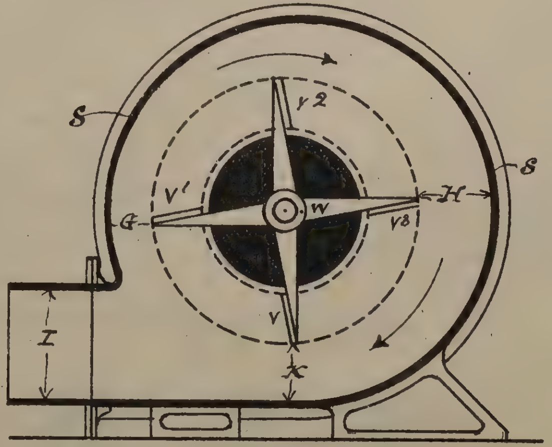
— CENTRIFUGAL FANS. DIAGRAMS SHOWING MISTAKES IN DESIGN. —

Shell with Extending Radius.



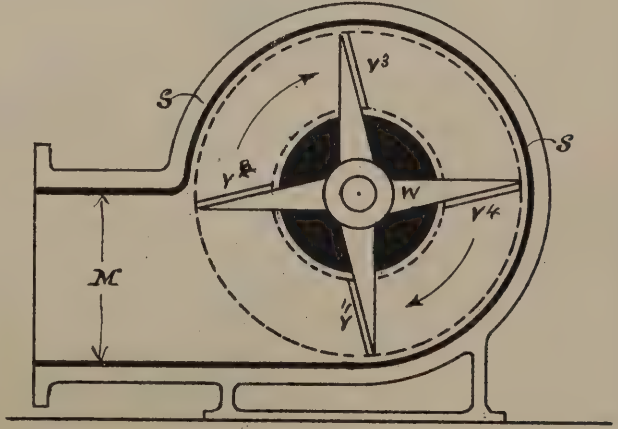
— Fig 1. —

Shell Eccentric with Wheel.



— Fig. 2. —

Shell Concentric with Wheel.



— Fig. 3. —

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PLATE XIa.

Centrifugal Fans. Ordinary "Sirocco" Type.

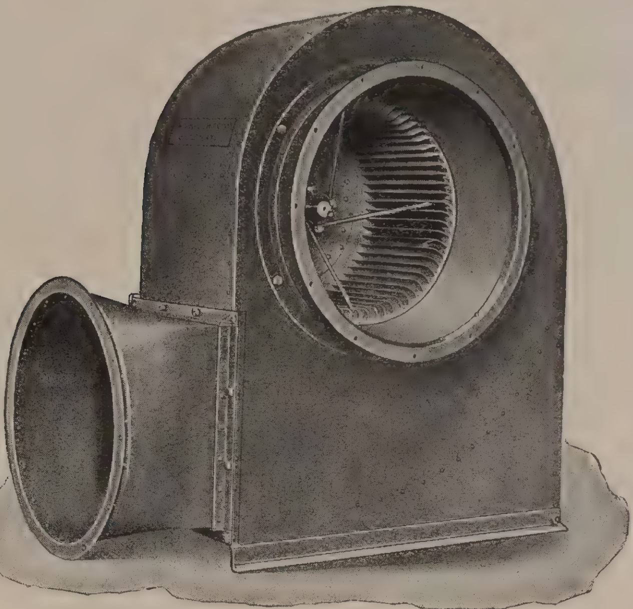


Fig. 1.

Showing suction eye and fan wheel in position.

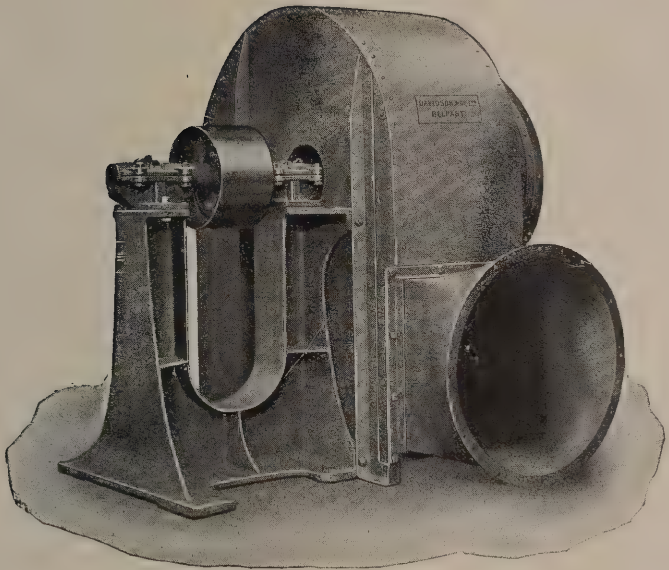


Fig. 2.

Showing reverse side of fan, with pulley and bearings.

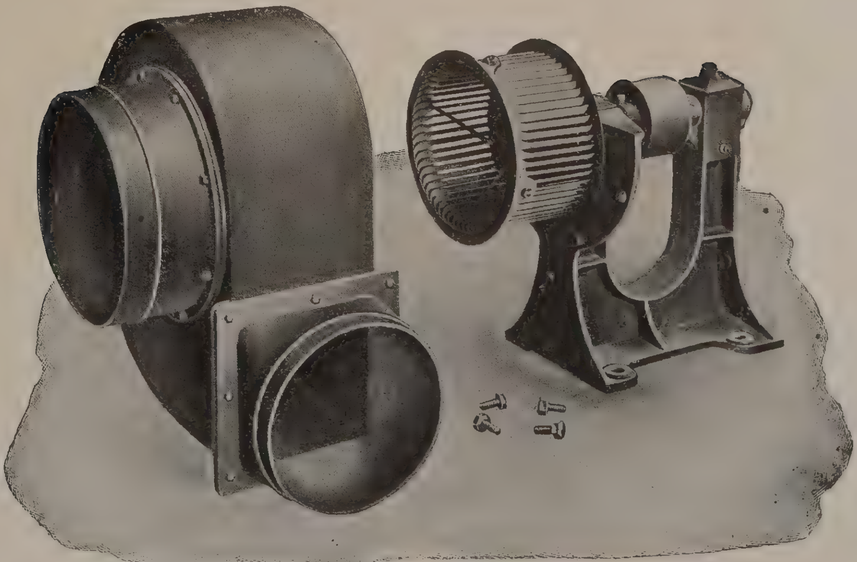


Fig. 3.

Showing separately casing complete and runner (or fan wheel) mounted on shaft.

PLATE XIb.

Large Centrifugal Fan. Fan for Dust Removal.

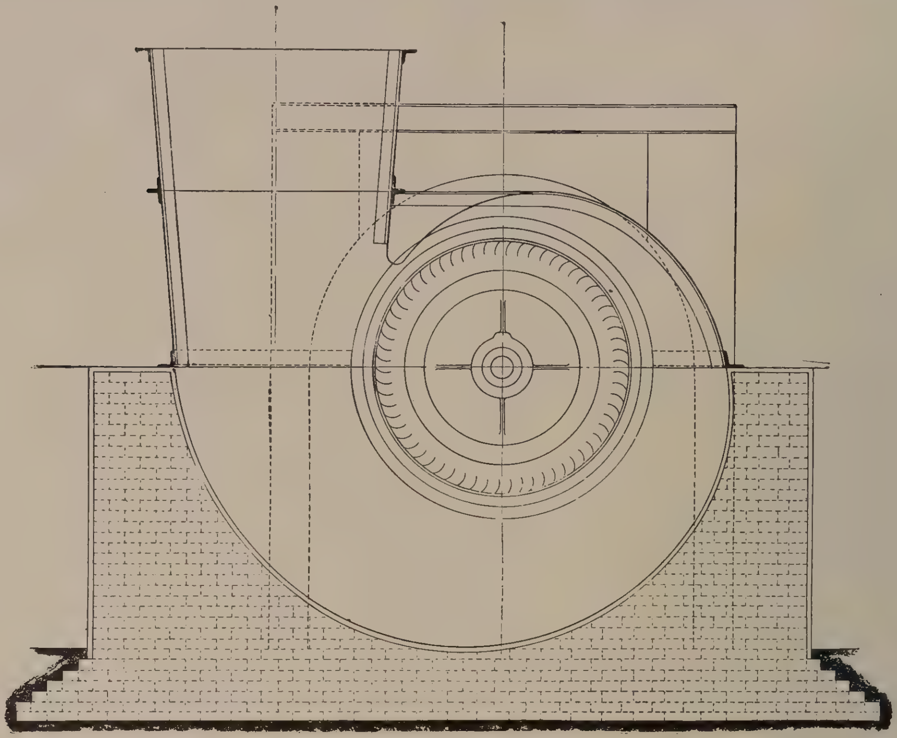


Fig. 1.

Section of large centrifugal fan ("Sirocco" type), showing space between the blades and casing, and trumpet-shaped outlet.

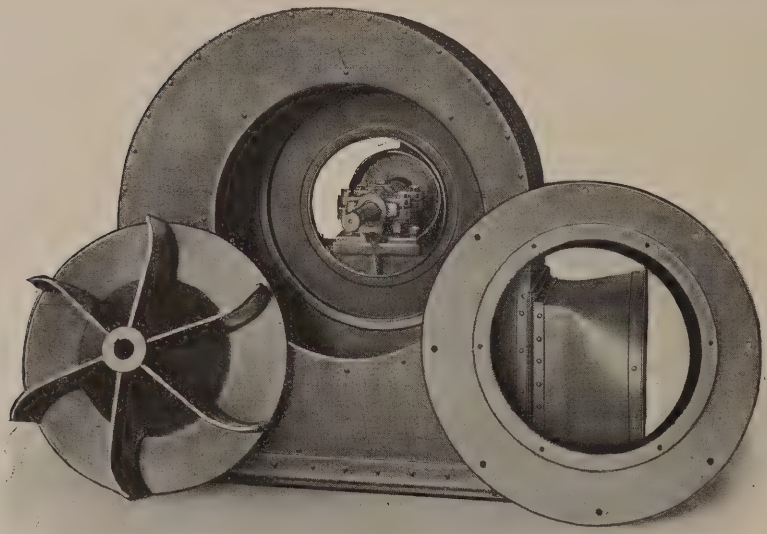


Fig. 2.

"Sirocco" fan for dust removal. Separate parts.

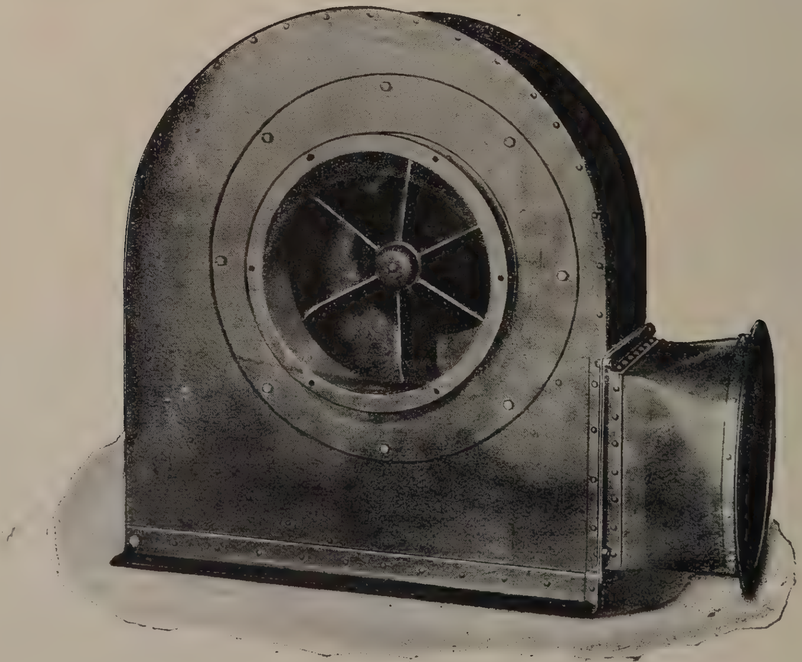


Fig. 3.

"Sirocco" fan for dust removal. View of intake.

PLATE XI.

Centrifugal Fans.

Diagrammatic sections of fans in general use.—In this plate three different designs are shown, the first being a correct form for fans working against low resistance, and the last two showing less correct forms which have been met with in the course of this inquiry.

Figure 1.—Diagrammatic section of a centrifugal fan showing a correct form of air space A, B, C, between the tips of the fan blades V^1, V^2, V^3, and the casing or shell S, S, which increases from a minimum at A to a maximum at the outlet D.

Figure 2.—Diagrammatic section of a centrifugal fan in which the air space between the tips of the blades V and the casing is badly proportioned. The cross-section of this air space at K is much too small, thus causing a resistance to the free escape of air from between the upper blades V^1, V^2, V^3.

Figure 3.—Diagrammatic section of what is practically the old form of winnower fan, from which (owing to the closeness of the casing to the fan wheel) no air can escape except from between the blades V^1, V^2, nearest the discharge opening M.

PLATES XIa and XIb.

Centrifugal Fans.

Plate XIa shows a type of centrifugal fan which is well designed for working advantageously against the moderate resistances commonly met with in connection with local ventilation in factories. The air is set in motion by the revolution of the numerous narrow fan blades mounted on the runner (Fig. 3), and consequently flies off at a tangent into the space between the blades and the case, and thence to the outlet at the lower part of the case. It will be seen that the design is such as to give a very free passage of air through the fan, and so reduce the internal resistances to a minimum. The fan can thus deal advantageously with large volumes of air against the moderate resistances usually met with in exhaust or inlet ducts of moderate diameter. It is specially suitable for cases where a propeller fan could not overcome the resistance, and where a centrifugal fan of the ordinary type and of equal size would be wasteful on account of its high internal resistance.

Figure 1, Plate XIb, shows a vertical section of a large sized fan of the same type. The shape of the space between the fan blades and case is clearly shown. The trumpet-shaped outlet tube in this and other types of centrifugal fan greatly reduces the velocity with which the air emerges to the outside, and so diminishes to a minimum the loss of energy which occurs when a fan delivers its air to the outside at a high velocity.

Figures 2 and 3, Plate XIb, shows a fan specially constructed to prevent blockage by fibrous dust, shavings, &c., or injury by solid objects such as pieces of wood. The vanes of the fan are solidly constructed, and there is no part on which fibres, shavings, &c., can be caught so as to cause obstruction. This fan when made, together with its case, in stout metal, and coated with anti-corrosive paint, is also suitable for the extraction of corrosive fumes.

Reference is also made elsewhere to another type of fan for dust removing purposes, suitable for users of small power in connection with metal polishing and similar trades (*see* description of Plate XXIIa, p. 31).

PLATE XII.

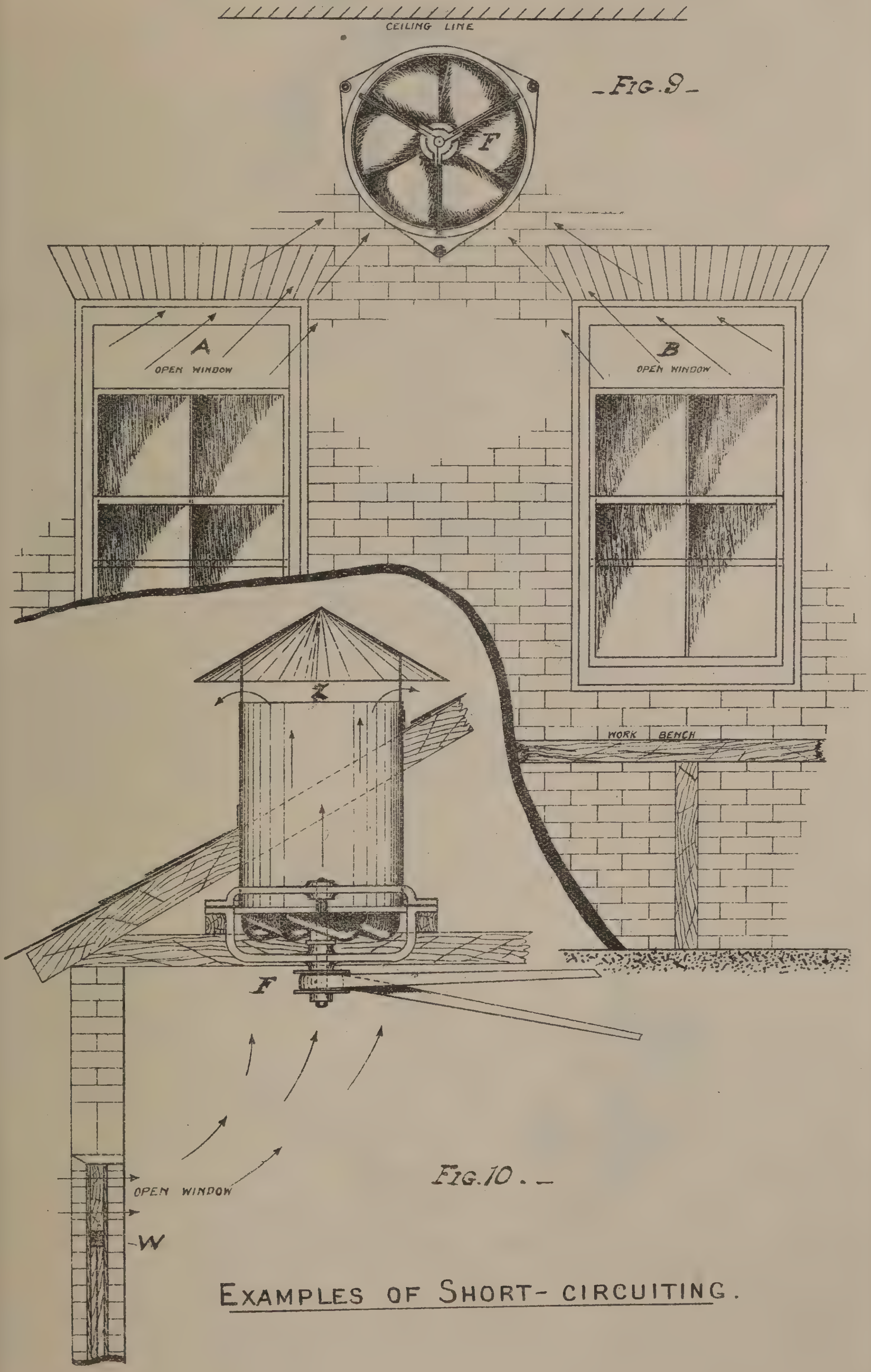
FANS UNSUITABLY ARRANGED—EXAMPLES OF SHORT CIRCUITING.

(*Drawn by H.M. Inspector, Mr. L. Ward, from sketches made by the Secretary.*)

In Figs. 6 and 7 of Plate X. it was shown how one form of short-circuiting takes place within the fan itself.

Plate XII. illustrates short-circuiting in another form, and deals with one of the commonest mistakes found in the fixing of fans, which is to place them in a position near some inlet or outlet which will more or less localise their effect; for instance in Fig. 9 the fan F is so placed with regard to the windows A and B, a few feet below, that if the fan is attempting to draw air from the room, a supply will immediately rush in from the open windows A and B, the result of thus locally supplying the fan with all the air it requires being to deprive the remaining parts of the room of any benefit. In such cases the air is said to short-circuit from window to fan, or *vice versa.* If extracting fans are placed near windows, care should be taken that the windows in the immediate vicinity be kept closed, and windows in some part of the room remote from the fan opened instead: the latter arrangement will ensure a supply of fresh air being drawn across the body of the room. A fan placed with its axle vertically is of course open to the same disadvantage if windows are placed almost immediately beneath it like the one in Fig. 10, where air, coming in through the open window W, takes a short cut in the direction of the arrows X Y through the fan F and outlet Z without having any appreciable effect upon the air in the room.

—FAN INSTALLATIONS UNSUITABLY ARRANGED.—



-FIG. 9-

FIG. 10.

EXAMPLES OF SHORT-CIRCUITING.

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FAN WITH RESTRICTED PASSAGES FOR EXHAUST.

FIG. 11.

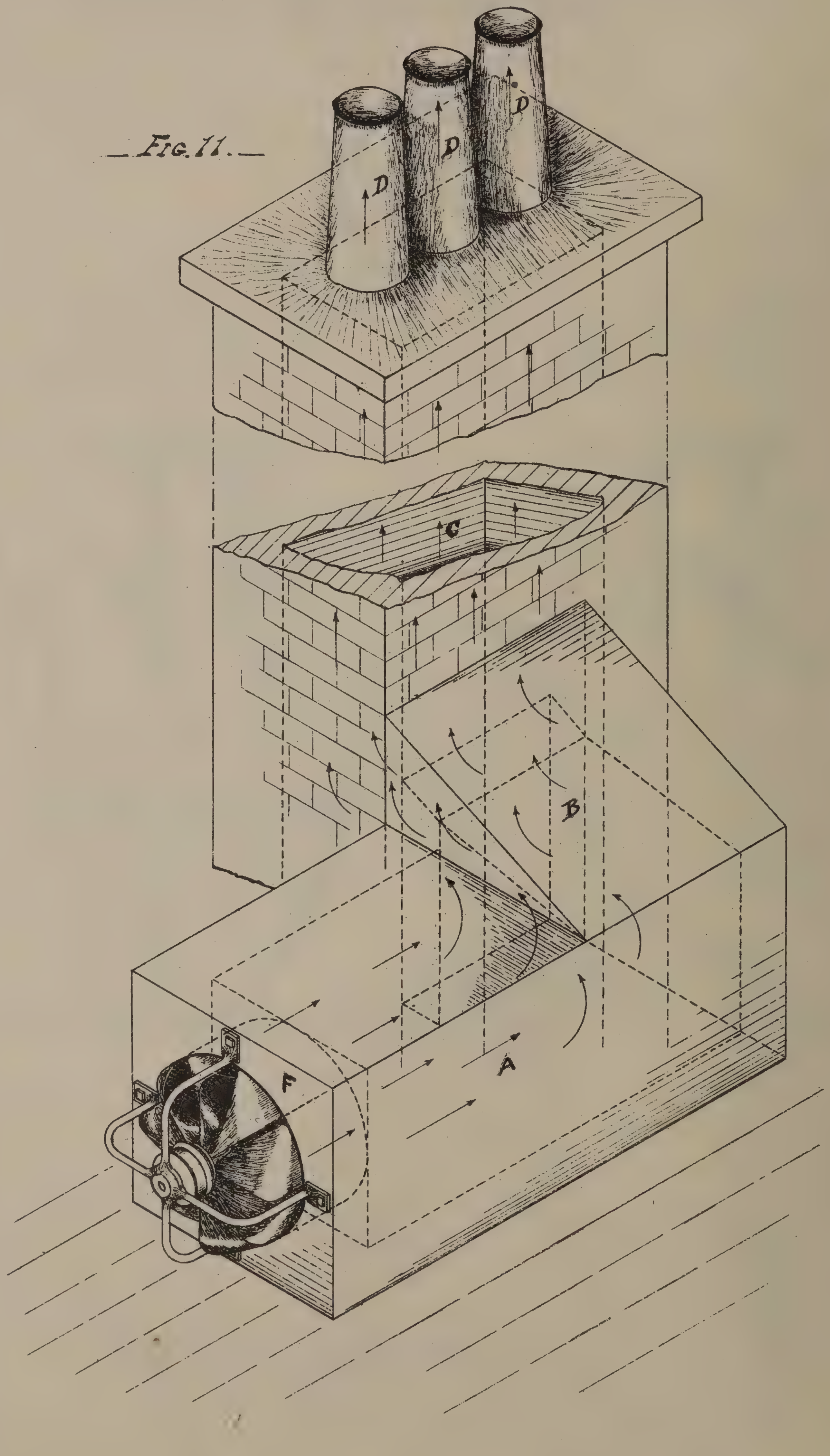

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PLATE XIII.

FANS BAFFLED BY RESTRICTED OUTLETS.

(Drawn by H.M. Inspector, Mr. L. Ward, from sketch made by the Secretary in a London Laundry.)

When dealing with the question of outlets for fans it is necessary to see that these are of proper arrangement and construction, or the fan may be set to do impossible work and the result be disappointing. Generally speaking the more direct can be the outlet from the fan to the external air the better will be the result, and this is particularly the case with propeller fans which have no fighting power against resistances. A typical case of very bad arrangement was observed by the Committee and is illustrated by Figure 11. A 24-in. fan "F" exhausting at a low level from a laundry ironing room had to force the air first through a horizontal brick passage, thence sharply round an inclined flue at right angles into a vertical chimney almost at right angles again, finally expelling what air it could through three small chimney pots, one covered with a stone. Needless to say the fan had but little effect in changing the air of the room. Such examples are by no means isolated.

PLATE XIV.

Encased Fans, etc.

(*Drawings by H.M. Inspector, Mr. L. Ward, from sketches made by Secretary.*)

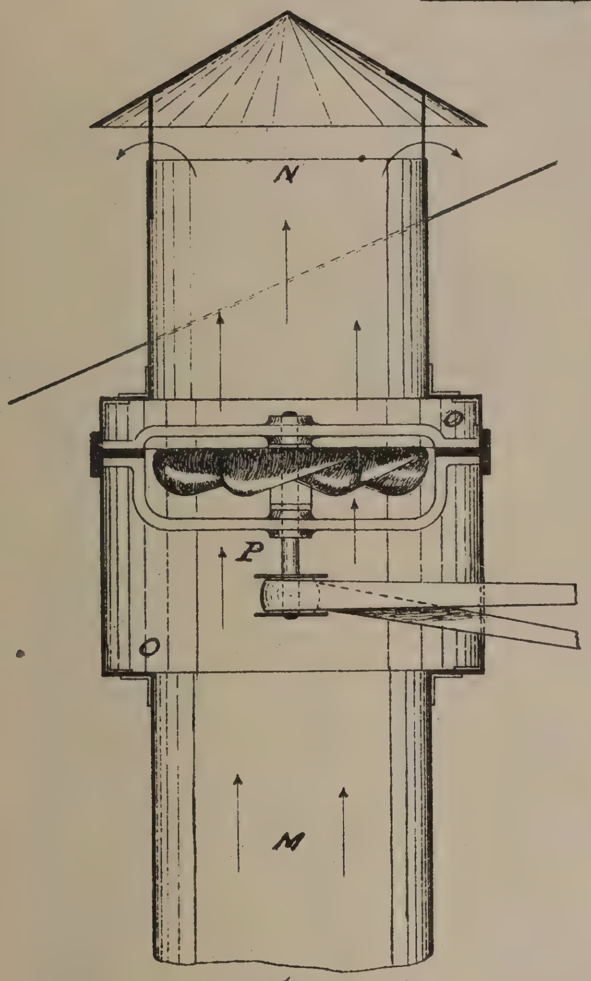
Whilst dealing with the arrangement of fans and their outlets another case observed by the Committee shows how unnecessarily trouble is sought by those who fix a fan in a way to give the worst possible result. In Fig. 13 a fan F is used to extract smoke, &c., from a range of forges and it is fixed in a galvanised iron casing of the section shown in the drawing. It will be seen from this that the smoke is drawn up through a pipe A into the fan box BB, and on its way to the fan it passes a rectangular corner which invites a deposit of soot at C. It then has to pass through the fan at another right angle to be blown with full force against the side of the uptake at D where it has another chance to deposit more soot and cause further obstruction, finally emerging after another rectangular swerve through the opening at E. The arrangement is all the more absurd from the fact that the fan F is much greater in diameter than the uptake A or the outlet E. In Fig. 12 the fan P is shown to be set in a much more reasonable position for the work it has to do; it is of the same size in diameter as the uptake M and the outlet N with a fan box OO slightly larger to admit of the frame. The more satisfactory working of such ar. arrangement can be foreseen at a glance.

Fig. 14 on this Plate shows an indifferent arrangement for removing dust given off from the processes of dusting enamelled iron plates and the like. The plate GG is placed on a grating H formed of horizontal bars at the top of a frame I and the action of a fan below is to draw the dust downwards (*see* arrows X). In the case of large plates however, so much of the grating would be covered by the plate itself that very little room would remain for the passage of air downwards and dust might therefore arise from the middle of the plate GG which would not come within the influence of the fan, especially so if the plate was brought forward to the edge of the grating nearest the worker. It is suggested that a better way of dealing with processes of this nature would be to cover the work bench with a hood Q Fig. 15, and then to draw the dust backwards from the worker (*see* arrows RR) to a duct S placed in or against the wall W and to dispense with the down draught altogether.

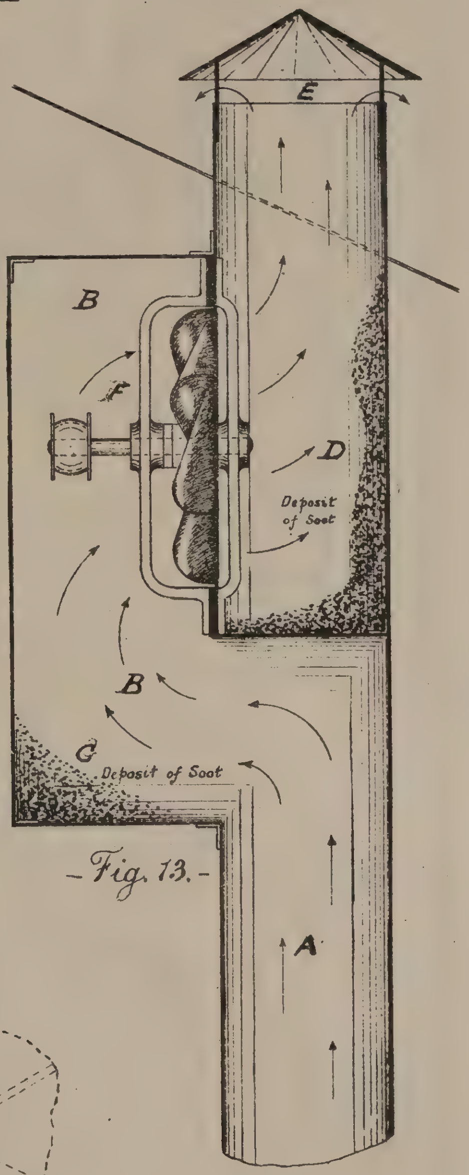
PLATE XIV.

CORRECT AND INCORRECT METHODS OF REMOVING SMOKE AND DUST.

NOT TO SCALE.



-Fig. 12.-



-Fig. 13.-

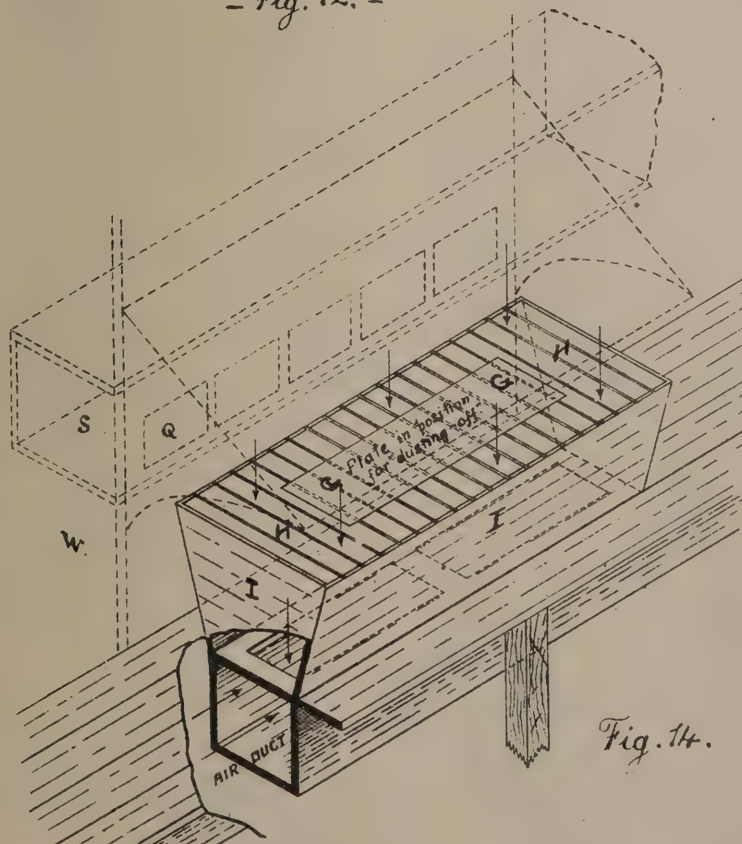
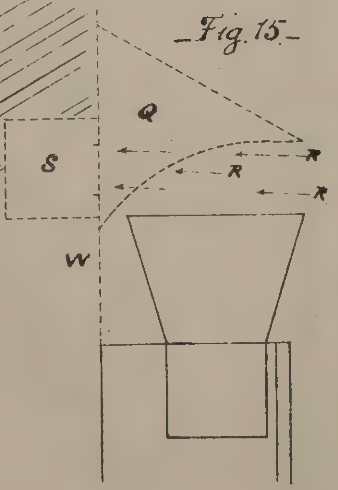


Fig. 14.



-Fig. 15.-

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Diagrams showing the waste of Material and Consequent Excessive Friction following the use of Small-Bore or Flattened Pipes and Ducts. Neglecting friction, the Amount of Air passed by each Duct A, C, or D would be identical with the Total Amount passed by the Ten Tubes BB, but the Surface of Metal composing the latter would be three times as great. —

Fig. 20 shows the Nett Effective Area (X) of an Opening YZ after allowing for Grid G

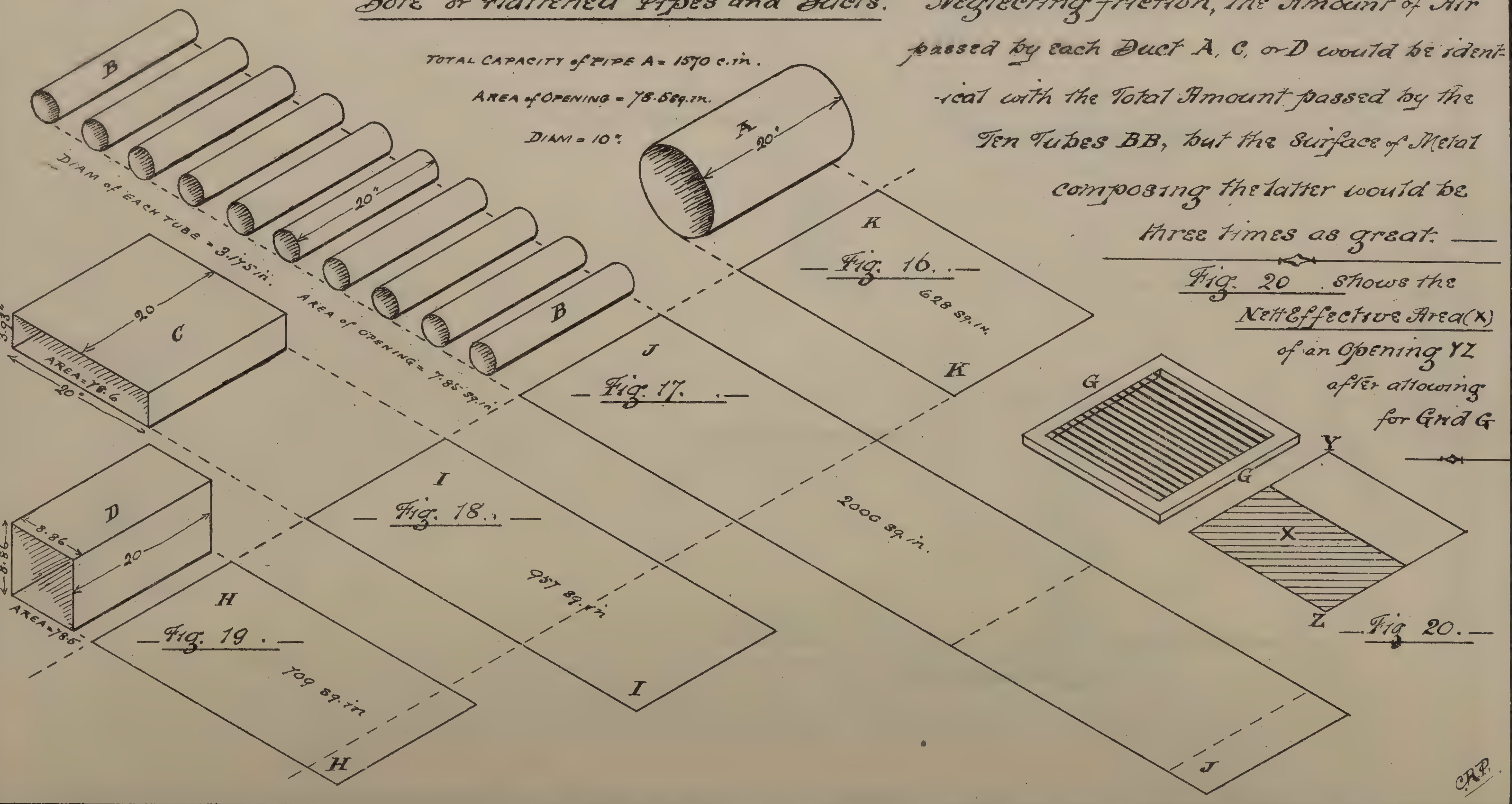

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PLATE XV.

ECONOMY IN DUCT CONSTRUCTION.

(Original Diagram Drawn by the Secretary.)

The illustrations on this Plate are designed to show how necessary it is to study the forms and dimensions of ducts and branches required for a given purpose. Generally speaking the best form of duct for use in extracting dust or fumes is a cylindrical or tubular duct made of galvanized sheet iron, steel, or similar metal, especially for use in connection with centrifugal or pressure fans ; for the larger sizes wood may be used, especially if the duct is required for large volumes of air for ventilating purposes only, but these wooden trucks are more liable to sustain damage from the effects of weather conditions, such as dampness, shrinkage, warping and leakage, and are not so easily cleaned and kept in repair. In some cases they may take the form of brickwork or concrete flues constructed in the masonry of a building, or even underground, but wherever and whenever they are used regard must still be paid to the proper turning and entry of junctions, and the most economical section of bore should be studied and adopted.

For nearly all purposes a plain tubular pipe of perfectly circular section such as is shown in Fig. 16 is by far the best, and, wherever it is possible, preference should be given to one duct of large bore rather than to a number of smaller ducts, the combined capacity of which would be theoretically equivalent to that of the larger one. Thus the 10 small pipes BB in Fig 17 are each 3·157 inches in diameter as compared with the 10-inch tube in Fig. 16 ; the diameters are therefore roughly as 1 to 3, but the areas of section being 7·85 square inches in each of the small pipes as against 78·5 square inches in the large pipe it follows that the actual carrying capacity is as 1 to 10. Again, the material used in the formation of pipe A (excluding lap) is 628 square inches, but the material (*see* JJ) used to make up the 10 pipes BB amounts to 2,000 square inches ; or shortly put, more than three times as much metal is required to pass the same volume of air (*see* Fig. 17). In passing through these 10 tubes, moreover, the air would be exposed to skin friction more than three times as great as it would in passing through the pipe A, a difference of very considerable importance, yet not generally sufficiently realized or understood. A duct of true square section such as D (Fig. 19) would require for its formation a sheet of metal HH, slightly in excess of KK (Fig. 16), so that a square duct is not so economical in metal as the tubular form, and is less desirable on account of the corners, which are much more likely to hold dust and obstructive matter. A duct of oblong section such as C (Fig. 18) is still less economical in metal and more objectionable for the same reasons, and the flatter this kind of duct the worse it is. The latter form of duct is the one generally used in what is known as Tobin Tubes, and often the opening at the top of these tubes is covered by a flat grid or grating formed either of bars, netting or gauze, according to size and requirements. In placing such grids over openings of this character sufficient regard is not often paid to the fact that they greatly diminish the effective area, and the capacity of a tube for the passage of air may be easily diminished from 30 to 50 per cent. by this cause. For instance, in Fig. 20 a quite ordinary bar grating GG placed over an opening 20 inches square (or 400 square inches in area) reduces the net effective area X to about 220 square inches, or but little more than half the area YZ of the trunk beneath. This obstruction can be minimised by making the grid " dish-shape," or placing it diagonally across the tube. *See* Plate XVI., Fig. 45 and 46.

PLATE XVI.

GENERAL NOTES ON THE PRACTICAL CONSTRUCTION AND USE OF DUCTS, HOODS AND GRATINGS.

(*Original Diagrams by the Secretary.*)

Arrangement and construction.

1. Generally speaking, ducts or air shafts should be as straight as possible, as round as possible, and as short as possible. They should be as large as is consistent with the current to be transmitted and as free from sharp bends or square corners as circumstances will permit. *See* Fig. 23, which is a permissible bend, as contrasted with the old stove pipe elbow, Fig. 21, or the sharp bend, Fig. 22, both of which should be avoided.

Strength and durability.

2. The metal of which they are formed should be of a gauge (or stoutness) commensurate with the work required, and in all respects suitable for the material they are required to transfer; lightest and thinnest for the mere passage of air; heavier and stouter for textile or animal and vegetable dusts; and specially strong for hot and acid fumes, mineral and metallic particles, &c. Wooden ducts may be used for some purposes, but should in general be avoided, as they are liable to derangement by atmospheric conditions, such as damp, heat, &c. By shrinkage, warping, knots falling out, &c., they become leaky; and they are also more bulky, and increase fire risks, &c. It is also less easy to construct them in well arranged curves.

Good and bad jointing.

3. All the sectional joints of a duct or pipe should be made of good fit and as smooth inside as possible, so that there shall be no leakage or obstruction caused by ill-fitting or ragged edges.

Internal smoothness.

4. In the case of lap joints the small end of one length of pipe should enter the socket end of the next length in the same direction as the current is intended to flow (*see* Fig. 25 on Plate XVI.); or the pipes should meet in a clean butt joint (Fig. 24).

Disconnection of branch pipes.

5. Where there are branches to a main duct it is a great advantage to have throttle valves at the junction of each inlet with the main pipe, because, when all are not required at once it saves fan power to completely disconnect those that are out of use. (*See* Fig 27.)

Subdivision of main pipe.

6. Sometimes it is useful to split the main duct itself into two or leading branches, with a Y-shaped junction (sometimes called a "breeches joint"), in which is placed a suitable switch plate or valve (A) to divert the current wholly or partially from one branch to the other. (*See* Fig. 26.)

Avoidance of obstruction.

7. These throttle valves, junctions and switches, need to be carefully made and fitted, or by the action of rust or corrosion they may become fixed, or otherwise inoperative and useless when required; or, if not internally smooth at edge and surface, specially in cases where fibrous material, shavings, &c. have to pass through them, they may cause obstruction by entrapping the material.

Facilities for internal cleaning.

8. In fitting up ducts, regard must be paid to necessary facilities for cleaning them out, especially at bends and junctions most likely to choke. Manholes and armholes should be provided at suitable points so that they can be easily cleared or examined; for even the best constructed ducts require periodical attention of this kind. *See* armhole with hinged lid and thumbscrew fastenings (Fig. 28).

Facilities for repair.

9. It is also advisable to arrange that any external part of the duct (even when underground) may be easily got at for examination and repairs.

Strengthening large ducts.

10. Although cylindrical or tubular ducts are generally the strongest, most economical and easiest to clean, &c., square ducts, or those of rectangular section, are sometimes the most convenient. In the larger sizes (say above 2 or 3 feet square) it is well to reinforce the sides with external stays to increase their strength and prevent collapse. This is better than increasing the gauge or thickness of the metal composing the duct itself.

Flexible metal pipes.

11. There are many cases in which flexible pipes can be used to great advantage, and these can now be obtained from certain makers. Attached to nozzles specially designed for handling (in much the same way as the household vacuum cleaner), such pipes can be put to a variety of uses,

Dust and air guides.

12. Many ducts and pipes used in dust extraction have a comparatively small bore, and some difficulty is experienced in collecting the surrounding air into a sufficiently narrow focus to enter it.

The most usual plan is to use a spreading "air guide" or "feeder," the outer boundary of which coincides with that of the area to be exhausted, and the apex of which coincides with the throat or branch pipe leading to the main duct.

Hoods for upward draught.

13. Such "feeders" or "air guides" may be of various shapes for various purposes; the conical funnel (Fig. 29), trumpet funnel (Fig. 30), bell-mouthed funnel (Fig. 31), or pyramidical hood (Fig. 32), are most frequently used for upward suction, as is also the porch hood (Figs. 35 and 36) when the in-take has to be one-sided. It is often an advantage to make the former funnels adjustable by means of a telescopic sleeve, sliding up or down on the up-take. (*See* Plate XLV.)

Hoods for downward draught.

14. The inverted cone (Fig. 37) or square hopper (Fig. 38) is more often used for downward extraction, wherever it is better to assist the gravitation of dust than to remove it backwards or upwards.

Hoods for backward draught.

15. The glazed verandah hood (Fig. 39) is useful in pottery and other work where the opening is in front and the main duct at the back, and where light is required to fall on the work in progress. The slipper hood (Fig. 40) is best for removing dust from polishing bobs, especially where the work is all done by lathes fixed on benches. Care must be taken to find the best angle at which to incline this hood, as the dust will not mount a slope too steep in pitch, and the angle varies for almost every individual case.

The flat nozzle hood (Fig. 41) is getting more into favour with experts for laminary ventilation of a purely local kind, a good instance of which is afforded in Plate XXXIII. (Fig. 93). It admits of many useful applications, and to ensure uniform suction over the breadth of the nozzle the area of the slot should be but slightly more than equal in area to the throat and if each slot can be provided with an inclined passage towards the fan so much the better.

The letter box slit (Fig. 42) is another form of air guide occasionally used, but a pipe similar in character to the nozzle just described must be used to connect it to the main duct, or the draught will not be properly focussed, and failure will result.

Funnels must not be too large.

16. When hoods, funnels and hoppers are used as air guides it is a common mistake to make them too large. No matter how they are constructed, the velocity of air-flow diminishes very rapidly towards the open end, and the larger the funnel or hopper the more will this fact tell.

Large pyramidical hoods, cone funnels and porch hoods can be used for smoke, hot-air, and such light bodies as have a natural tendency to rise, but for heavy particulate matter and the heavier fumes smaller hoods, and more of them, will be found much better; for instance, to ventilate an area of 1,000 square inches, instead of using one hood having an are of 1,000 square inches and a duct of 64 square inches, it will usually be better to use four hoods of 250 square inches each with ducts of 16 square inches each. (*See* Fig. 34 in contrast to Fig. 33).

For the mere purpose of gathering air into an inlet it is not necessary to have a very wide funnel. A gradually tapered or bell-mouthed inlet with the mouth about twice the area of the throat will be generally sufficient. The same applies to removal of fumes from a limited area, such as metal pots on linotype machines, exhaust openings on collar-ironing machines, &c., &c. (*See* Plates XLII. and LII.).

Sweep holes.

17. Wherever an installation for extracting dust is in force it is convenient to have one or more sweep holes at suitable points at the floor level, each connected with the exhaust trunk, and covered with a suitable lid. These afford a ready means of removing floor refuse, as shown in Fig. 43.

Grids or gratings.

18. When these are placed over the entrance to a duct or air shaft it is often a good plan to place them diagonally across the opening (Fig. 45) rather than perfectly flat (Fig. 44); by this means a more effective area can be obtained for the entrance of air and a better filtering effect accomplished at the same time. Or the filter can be "dished" as in Fig. 46.

PLATE XVI.—*continued.*

Fig. 47 on this plate shows a diagrammatic section of the fan more fully described on Plates IV. and V. During the experiments with the main duct M and the shutters *a*, *b*, *c*, *d* it was found that when every opening or inlet to the fan was closed there still appeared to be a moderately strong current of air issuing from the discharge side of the fan ; but on closer examination it was discovered that all the air moved by the fan went in and out of the same passage, as shown by the positive and negative arrows P and N in Fig. 47.

This was clearly proved by placing a small pile of dust on the floor of the fan-casing at K. With the inlets (G) fully closed, the dust partly remained where it was and partly was drawn into the fan ; but on G being opened ever so slightly the direction of the current N was at once reversed and the dust blown away to a considerable distance.

The current perceptible to the hand when placed over the fan outlets is therefore an insufficient indication that the fan is working properly and the inlets fully open, and some more exact test should always be employed.

DETAILS OF DUCT CONSTRUCTION, AIRGUIDES ETC.

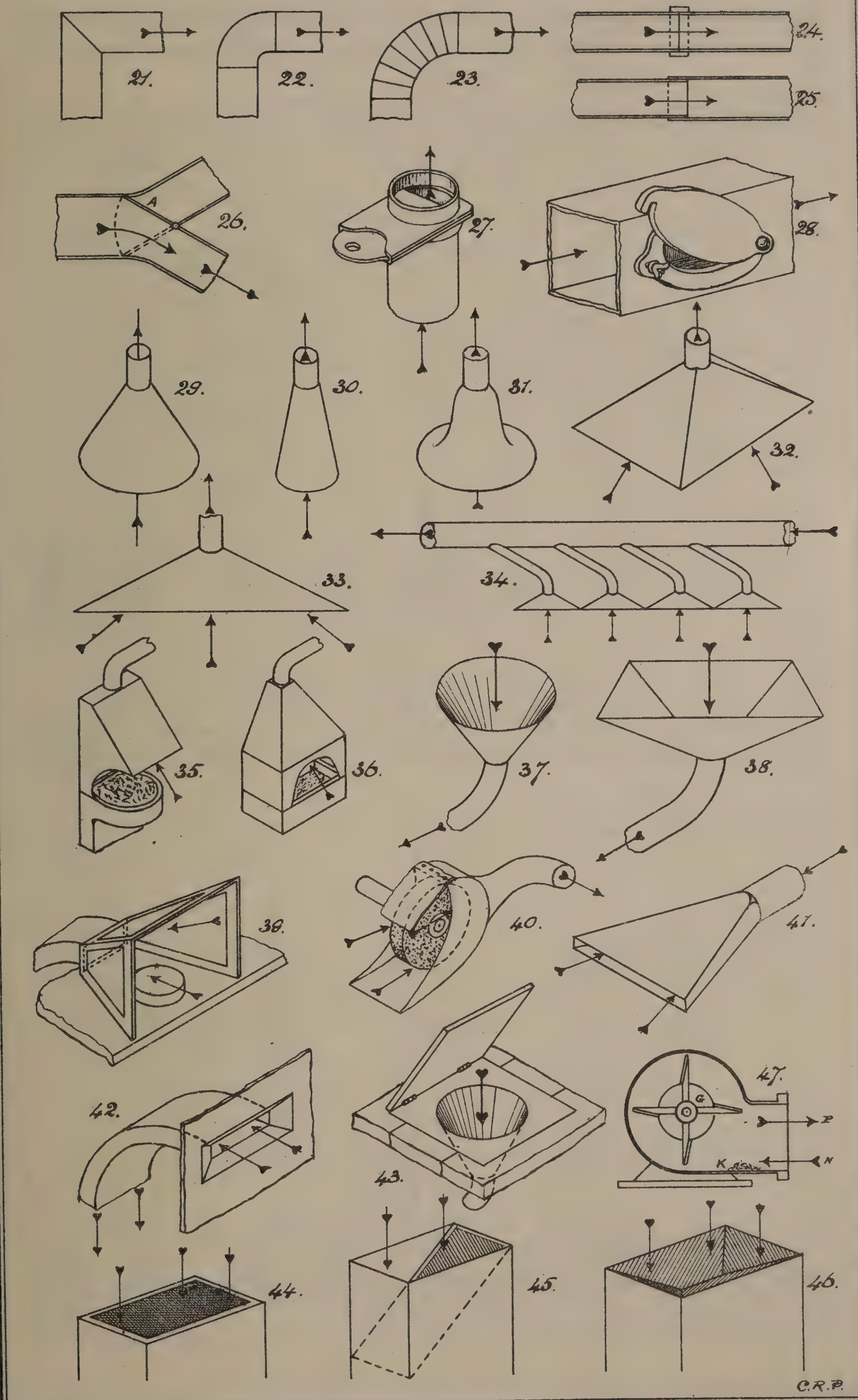

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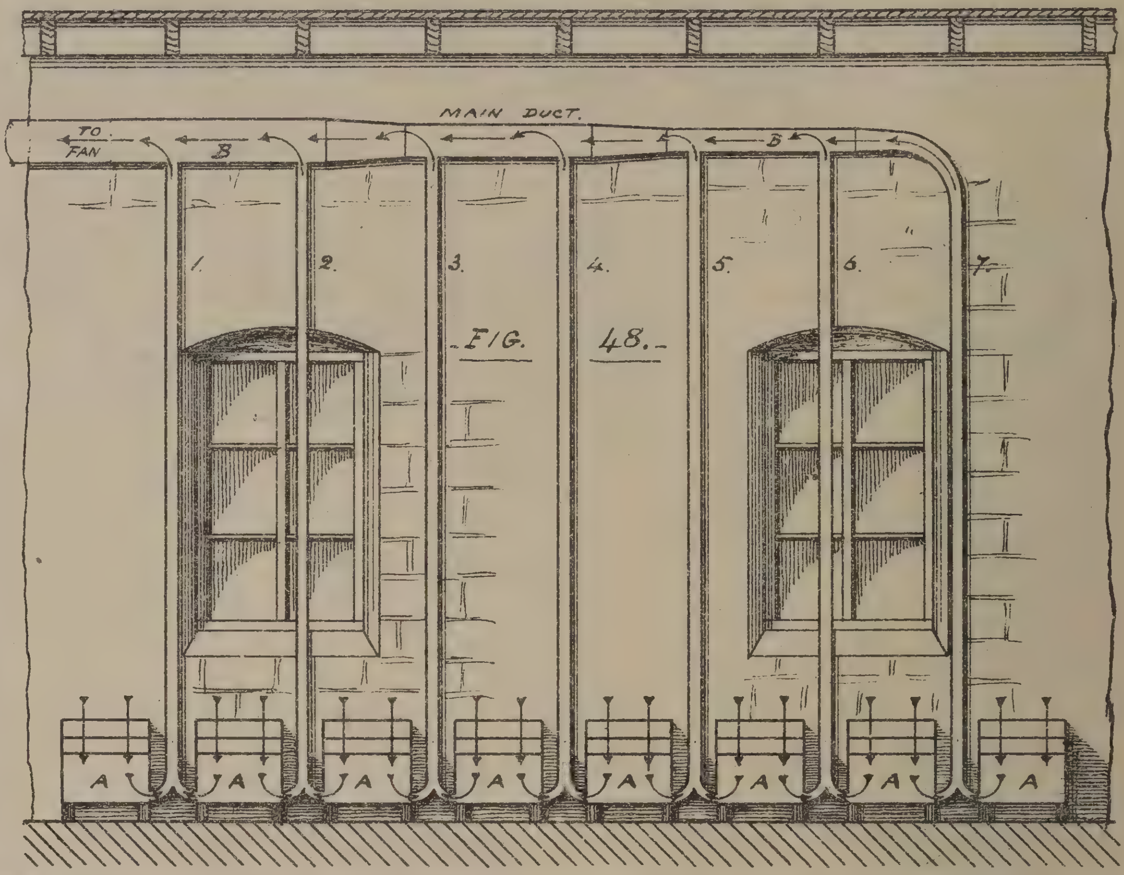
PLATE XVII.

—WASTEFUL MULTIPLICATION OF SMALL PIPES. ETC.—

SECTIONAL DIAGRAM — FIG. 48.



A BETTER ARRANGEMENT FOR EFFECTING SAME PURPOSE.

SECTIONAL DIAGRAM FIG. 49.

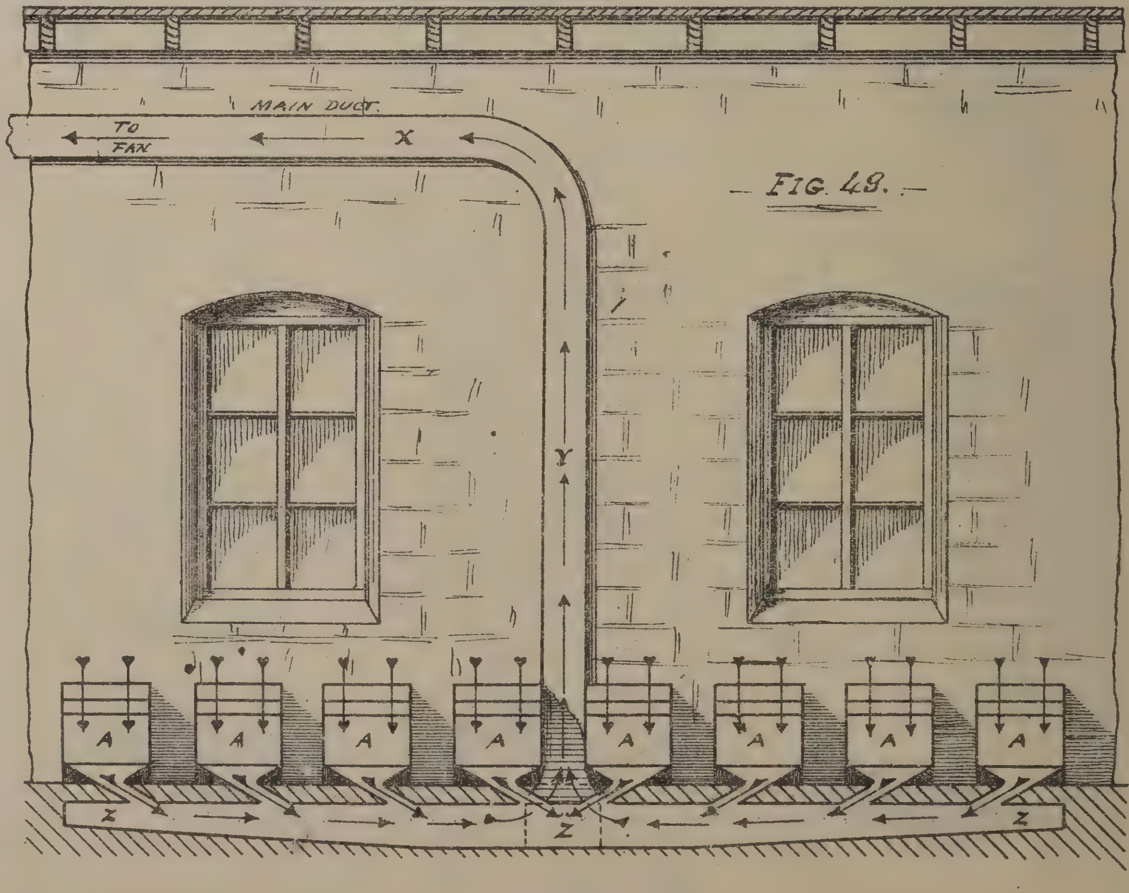


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PLATE XVII.

WASTEFUL MULTIPLICATION OF SMALL PIPES, &c.

(*Original diagrams by the Secretary.*)

Having in view the foregoing remarks on the economical construction of ducts, a glance at the arrangement shown in Fig. 48 on this Plate will assist in understanding some conspicuous faults in the system which it represents.

Eight dusty machines A A A A A A A A are placed in a row against the factory wall, and each is covered with a metallic casing to keep the dust within narrow limits. The problem is to exhaust each metal casing thoroughly and equally by means of a powerful centrifugal exhaust fan placed outside the room.

In this case it is done by having an overhead main (tapered) duct B B extending nearly the whole length of room beneath the ceiling. To connect this overhead duct with the covers of each machine a small branch pipe (one-seventh the capacity of the main) is brought down between the frames, and each joined by right and left elbows to the covers which are to be exhausted; there are thus in use seven long small-bore pipes, each having three elbows (one at top and two at bottom). This unnecessary length of piping and multiplication of elbows is highly detrimental to the exhaust current, and only one or two of the machines nearest the fan are properly served.

A more correct method of achieving the object in view is to carry the main duct with undiminished bore as near to the centre of the system of machines as possible, and if it can be carried beneath them so much the better. It can then be made to branch out right and left into two large branches Z Z, and these in turn may be connected by short slanting throats to hoppers which form the bottoms of the casings to be exhausted.

The dust generated in each machine has a tendency to drop downwards, and the suction underneath encourages this natural gravitation; the hoppers serve to collect the dust to a central point in direct communication with each throat, and here the exhaust current is sufficiently good and uniform to draw it away.

By this means all abrupt curves and narrow elbows are avoided, the piping used is about five times shorter in length, and the friction is materially lessened throughout.

In ventilating a series of machines like this, one of the drawbacks most often found is the impossibility of getting a duct such as Z Z (Fig. 49) underneath the machines. If designers of machinery used in dusty processes would bear the statutory insistence on adequate means of dust removal in mind, they could often so arrange the framework as to facilitate the introduction beneath any machine of necessary ducts and appurtenances without interfering with the machine's efficiency. At present it either means—

(*a*) Exhausting upwards in the least satisfactory way; or

(*b*) Raising the machines on pedestals; or

(*c*) Piercing the floors to get beneath them—methods that can only be carried out at the expense of stability or inconveniences of some other serious kind.

PLATE XVIII.

ROOF VENTILATORS AND SIMPLE INLETS AND OUTLETS FOR FANS.

As stated in their first report, the Committee advocate the use of the simplest contrivances as air inlets or outlets for external use ; complicated arrangements and those dependent upon the action of the wind for their operation being often most operative when least required, and *vice versa.* In Fig. 50 an ordinary revolving cowl C is shown in use as an outlet. It is pivoted at M and is free to rotate as shown by the dotted lines. The mouth is surmounted by a vane V, which keeps the outlet always in the lee of the wind (*see* arrow W) and so assists the outgoing current by aspiration. The barrel M contains no archimedean screw, but affords an almost clear passage for the air. Fig. 51 is a fairly simple and free outlet made of galvanised iron of the kind in use at Woolwich Arsenal ; it may, or may not, be used with a circular diaphragm or snowplate A, sometimes inserted in the position shown to arrest the descent of snow or moisture where such may be expected. There is room for doubt as to the value of this extra, but if used at all it should be fitted with gutters to carry off the melted snow or rain to the outside. Care should also be taken that the annular space around the disc should rather exceed in capacity the bore of the tube it surmounts. Fig. 52 shows a somewhat similar arrangement with an adjustable diaphragm or disc B. When placed vertically on edge the disc B admits the full passage of air, but when placed on its flat, air may be excluded either totally or partially according to the angle at which it is posed. The disc may be operated from below by means of a right and left crank P, connected to ropes or wires. Fig. 53 shows an ordinary form of wooden ventilator, consisting of a turret with louvred boards C, C, either adjustable or not as may be required. The foregoing are taken as fairly good types of the simpler outlets generally found in use ; and anything more complicated is not to be recommended. Indeed, it is questionable if the purely simple device shown in Fig. 54 is not as good as any where an always open vent can be employed.

Sometimes, however, it is necessary to guard the inside of a building from an inrush of cold damp air at night, &c.; this requirement has to be met by special appliances, some of which are illustrated.

Fig. 55 shows a special form of non-return roof ventilator devised by Mr. Hart for use with his humidifying fans. It is undesirable when work ceases during mealtimes, or when the works close at night, that cold damp air should find its way into weaving sheds untempered by the action of the steam and fan below, the latter then being stopped ; consequently a baffle plate or disc D is so arranged at the top of a circular turret or opening that it hinges unequally on a pivot E, the smaller portion of the disc being fitted with a balanceweight F sufficiently heavy to bring the disc to a horizontal position when the air pressure is equal within and without. Contrariwise, when the pressure inside the turret is reduced by the fan the atmospheric pressure without will act in the direction of the arrows at D and force the disc open to a position indicated by the dotted lines. This appliance can be used with a vertical outlet only, but in Figs. 57 and 58 a form of split diaphragm, acting in a horizontal outlet tube, is made to accomplish the same purpose. The pivot on which the two parts hinge is inclined slightly backwards at the top, as shown in Fig. 58 at H, and as long as the fan exercises pressure from the inside of the tube K K the two halves of the diagram H and I will remain open as shown, but directly the pressure from the inside is relieved the two halves H and I will fall back and cover the hole.

A frequent source of trouble in connection with fans is the back pressure exerted by wind when the fan outlet emerges from a building in an exposed position.

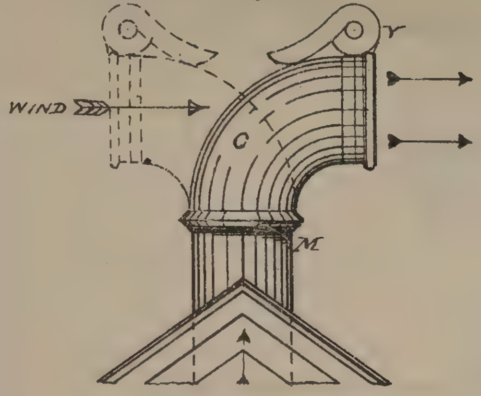
Fig. 56 shows a form of wind guard which may sometimes be used to effect a remedy for this drawback. The fan outlet O on reaching the outside is curved downwards, and immediately below the opening a semicircular shield G G is attached to a concentric pivot S carried by a bracket R attached to the wall. This wind guard can be revolved round either by hand or automatically to oppose the wind at any point of the compass (*see* arrows W W W).

PLATE XVIII.

—Simple Air Inlets and Outlets, for Use with or without Fans.— Self-Closing Outlets and Wind-Guards.—

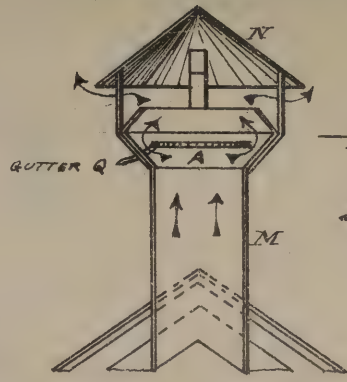
—Fig. 50.—

—Revolving Cowl.—



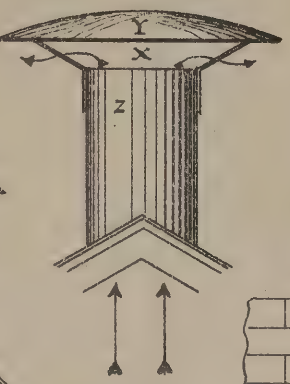
—Fig. 51.—

—Fixed Diaphragm A.—



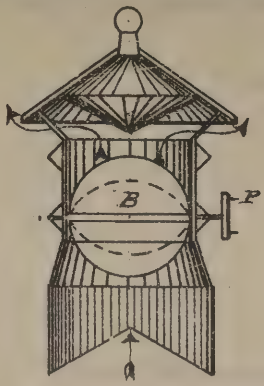
—Fig. 54.—

—Simplest Outlet.—



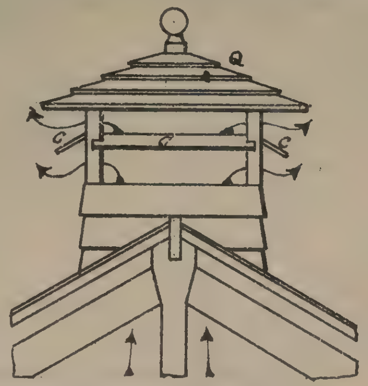
—Fig. 52—

—Adjustable Diaphragm B—

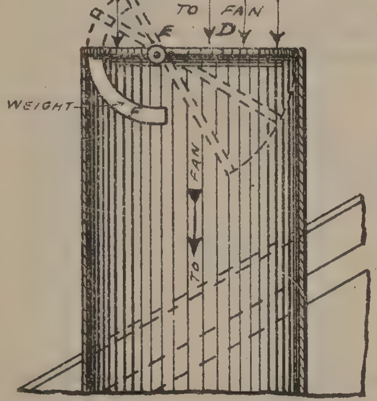


—Fig. 53.—

—Louvred Weatherboards.—

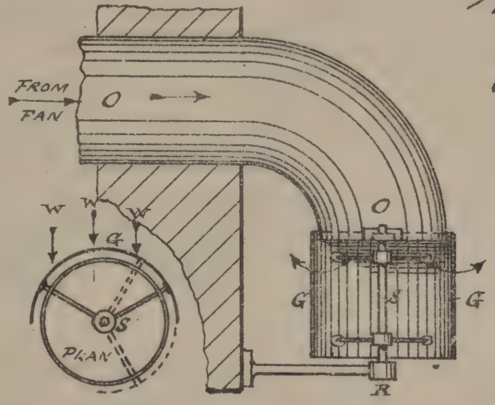


—Fig. 55.—



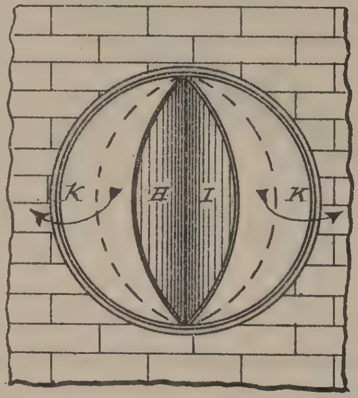
—Harts' Self-Closing Diaphragm D.—

—Fig. 56.—

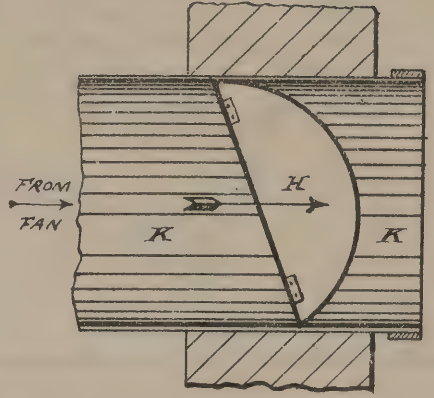


—Wind Guard G for Fan Outlet O.—

—Fig. 57.—



—Fig. 58.—



—Self-Closing Split Diaphragm for Fan Outlet.—

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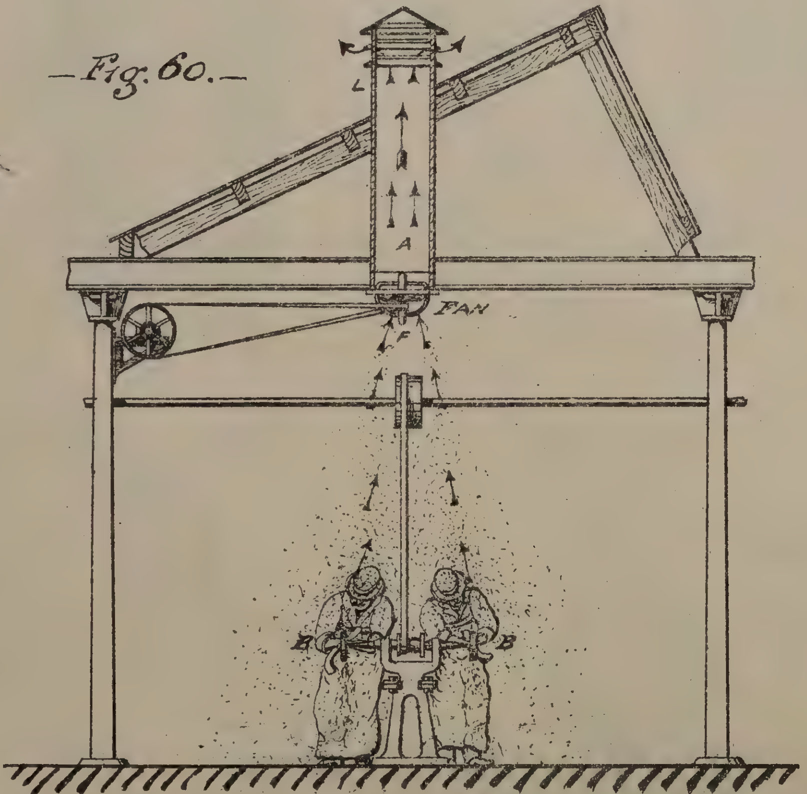
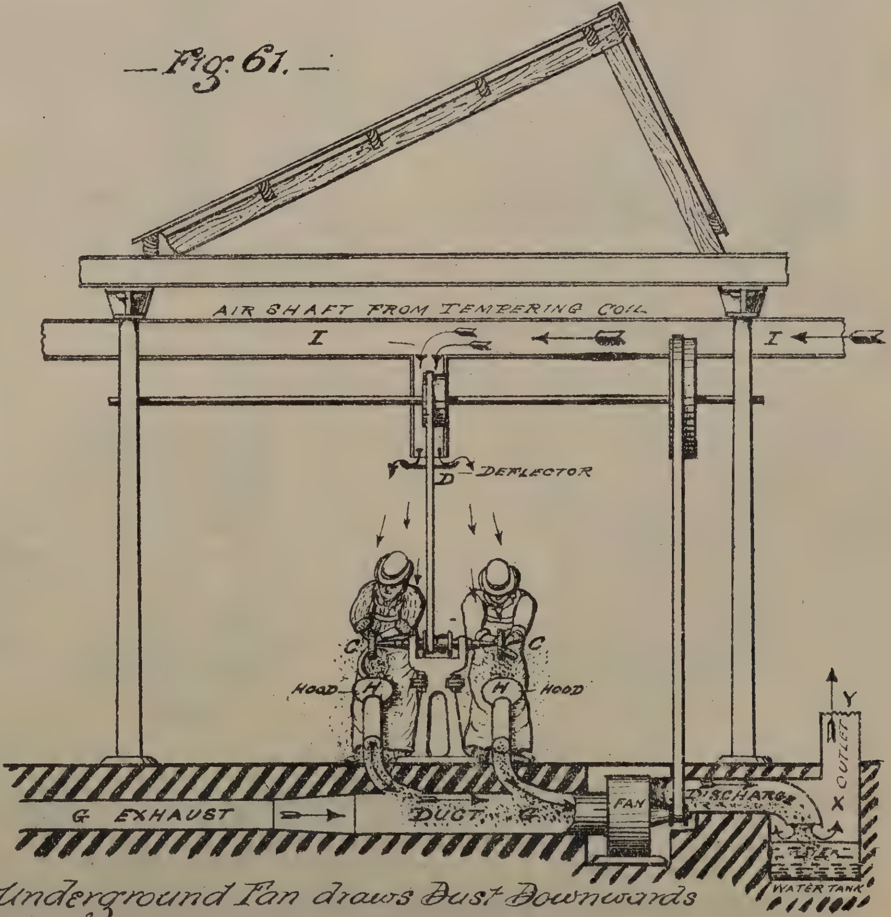
Comparison of Two Methods of Extracting Dust. Upwards versus Downwards.

—Fig. 60.—



Overhead Fan keeps Dust in Suspension, or Draws it Upwards past Faces of Workmen.

—Fig. 61.—



Underground Fan draws Dust Downwards through Hood, and Brings in Fresh Air from Shaft above.

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PLATE XIX.

DRY GRINDING AND METAL POLISHING.

(*Drawings by the Secretary from sketches made in various cycle works.*)

It has long been recognised that the dust from grindstones, emery wheels, and other metal polishing machinery, is of an injurious nature, and should therefore be kept as much away from the respiratory organs as possible. Many methods have been adopted at various times, some foredoomed to failure, and others with only partially successful results. Most prominent amongst the failures are those attempts to deal with dust by means of an open propeller fan; by which is meant a fan fixed in a wall, window, or roof, without the assistance of any collecting hoods, trunks, or air guides. Fig. 60 shows an instance found in a large cycle works. Immediately above every pair of polishing bobs B, B a fan F was placed to draw air upwards and expel it through the louvre L in the roof. The unsatisfactory result of this was that dust given off by the wheels, instead of being encouraged to gravitate towards the floor, was kept more or less in suspension, the lighter particles being drawn upwards past the workers' faces, so that their hair, faces, and clothing were covered with it. In another cycle factory the arrangement Fig. 61 was tried; an underground duct G G was exhausted by a fan discharging into a tank of water. Leading upwards from the duct G were branch pipes terminating in a metal bell-mouthed telescopic hood, the middle of which could be raised or lowered to be near the polishing wheel or not, according to the work being done. It was found unsatisfactory from the fact that the workers would not keep their hoods sufficiently near the wheel to be of much benefit, and more often than not used the bell-mouthed inlets as convenient receptacles for tools and other things, thus checking the draught. Some better arrangements for hoods in this connection will be found in later illustrations. It should be borne in mind, however, that when fans of any kind are used in extracting dust, fumes, &c., from a given workplace, large quantities of air must of necessity be withdrawn from the room, and convenient inlets should in all cases be provided to supply the deficiency, otherwise the good effect is lessened. Windows are not always available and seldom satisfactory when they are, because the air forcibly drawn in through them is apt to cause unpleasant local draughts. The best means of introducing air for this purpose is generally by means of an air-shaft, such as I, Fig. 61, having a heating battery or temporary coil at its inlet, so that the incoming air can be made to enter at a temperature causing the least possible inconvenience to the worker. At the opening of such a shaft into the room a deflector like that sectioned at D is useful in giving a fountain-like spray to the descending currents of air.

PLATE XX.

Fettling Castings.

(Drawing made by Secretary from plans furnished by Messrs. The Bristol Wagon and Carriage Company, Limited, Bristol, Mr. R. Stotesbury, Engineer.)

Amongst the dry-grinding processes, one of the commonest and easiest to deal with is the fettling of iron castings by means of emery wheels in foundries, &c., especially where the wheels are made to rotate over and downwards towards the work being ground. A set of wheels of this character will be seen in Fig. 62, with a successful installation of ducts and hoods connected with a powerful " Sirrocco " fan for extracting the dust. The hoods H are made to envelope as much of the wheel as possible (*see* Fig. 64), and at the top part of the hood an adjustable slide S is fitted, which can be shut down to any position as the wheel wears, air being drawn in between the shuttle and the wheel as indicated by the small arrow. Similarly on the under-side a hinged valve G is provided with a lever on the outside, by means of which the valve can be closed as the wheel wears. Most of the grinding is done on the rest R, but some is done higher up on the wheel, and it is for this reason that the wheel cannot be more completely covered, as may be done in the case of a smaller wheel like that shown in Fig. 63, where the hood H is fitted with a hinged cover C, and very little of the wheel is left open. The hoods used in this installation are made partly of boiler plate strengthened by angle iron, so as to serve the double purpose of safeguard and air-guide combined. The neck or throat N leading to the main duct E is curved towards the fan so as to give a little lead to the air current. Each throat is also provided with a check valve C V to disconnect or regulate the air current in case of necessity or repairs.

The main duct itself is embedded in a trench, and is connected to a Sirocco fan, which discharges the dust into an underground water tank with a vertical vent for the spent air.

Extracting Dust from Enclosed Emery Wheels, with Tapered Underground Main Duct, for use with Centrifugal Fan.

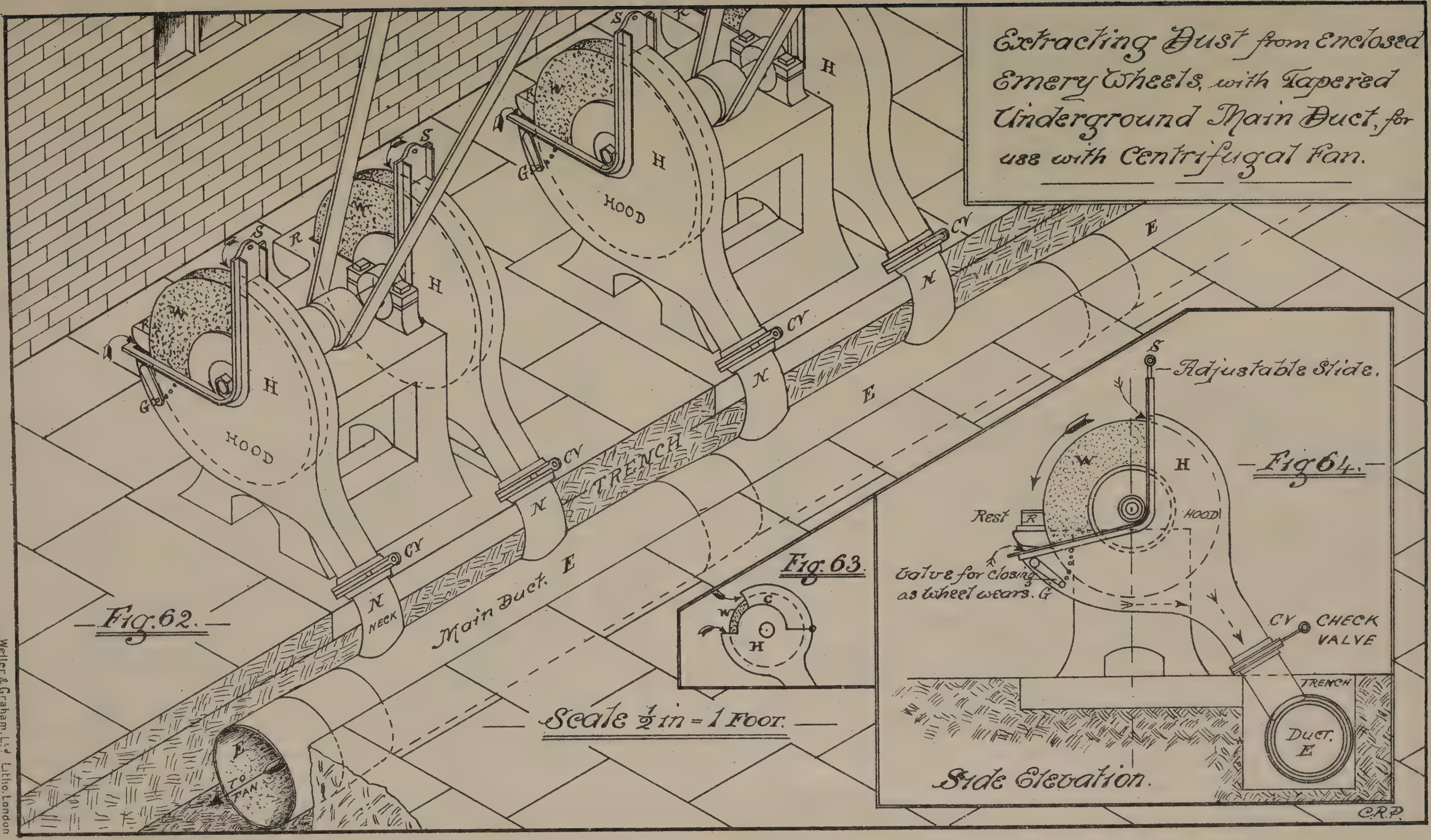

Fig. 62.

Fig. 63.

Fig. 64.

Side Elevation.

Scale ½ in = 1 Foot.

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PLATE XXI.

Fig. 65. Half-hinged Hood for Polishing Tubes & awkward work.

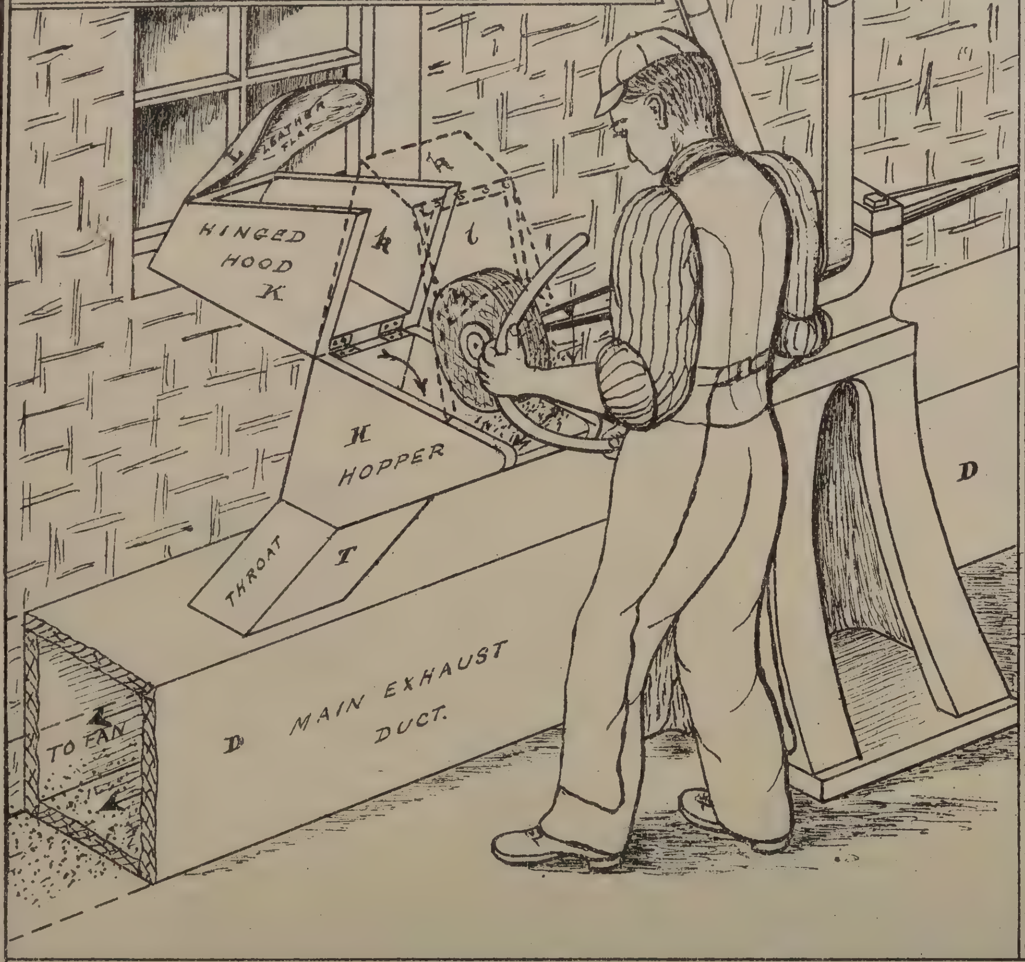
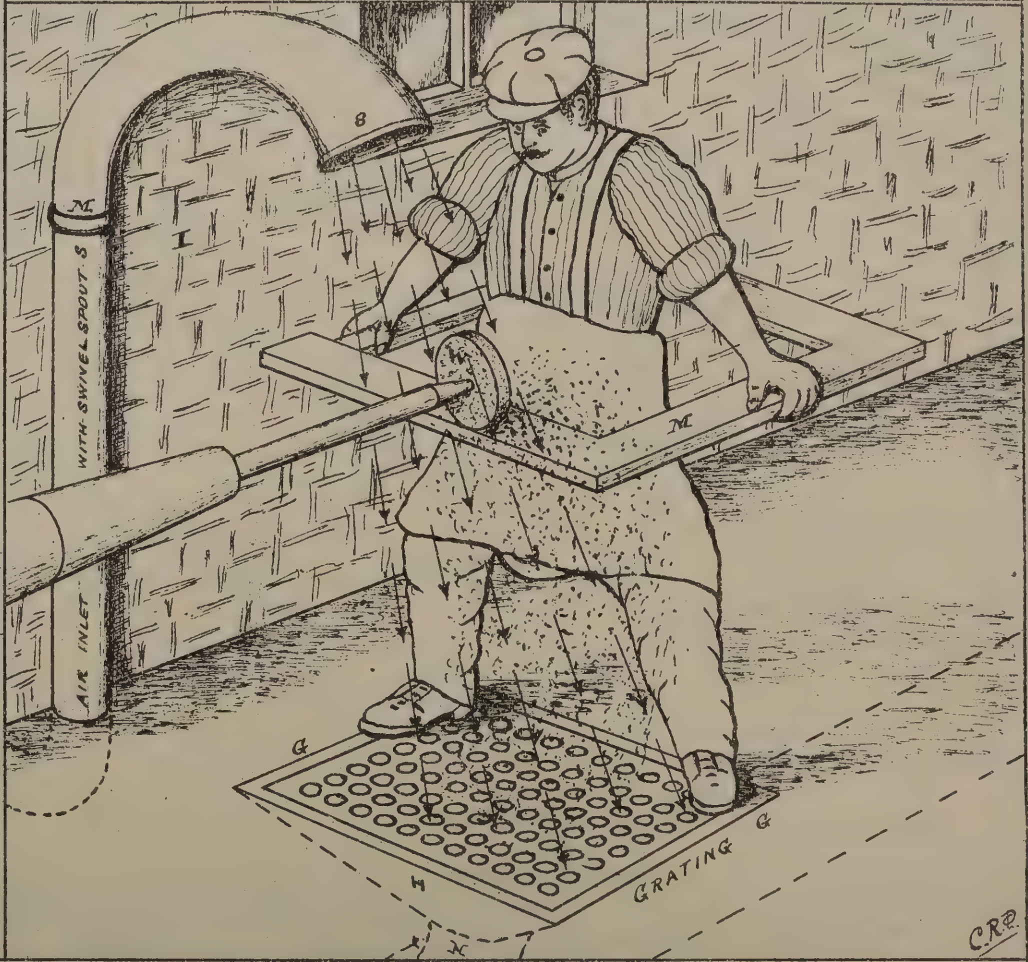


Fig. 66. Stove-grate, and Mantel Polishing:- Suggestion for Inlet, with Down-draught Extraction of Dust.



—Common Difficulties in Dry-grinding and Metal-polishing, where work has to be done "all over the wheel."

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PLATE XXI.

STOVE GRATE POLISHING.

(*Sketches by the Secretary.*)

Fig. 66 shows a Sheffield grinder in the act of "cleaning up" a cast-iron mantel-frame, which has to be done by means of a small emery wheel W revolving at the end of a long spindle; and, inasmuch as the man requires to place his work at any position on the wheel, no kind of hood or air guide can be used. The dust given off contains much founder's sand in addition to the iron and emery particles, and the man has to work with his face rather close over the wheel. Such processes might be rendered less harmful if they could be done over a grating such as G with a hopper beneath it leading to an underground duct exhausted by a fan. An inlet in the roof above, as shown in Fig. 14, Plate II., or even a swivel inlet on the wall, as shown in Fig. 66 (which could be turned to the wall when not in use) would be helpful in throwing a descending current of air over the wheel (as shown by the arrows) to join the exhaust current generated by the fan, thus carrying the dust downwards and away from the worker, at the same time bringing him an adequate supply of fresh air. To ensure the successful working of this arrangement it would be necessary to close other inlets or openings in the room, unless the inlet was itself supplied by a fan.

Fig. 65 on this plate illustrates an easily contrived arrangement for "bob polishing" in small works.

The polishing "bob" or wheel W is covered by a hinged hood K which can be thrown over to cover the wheel almost entirely as in the position indicated by the dotted lines k k; the better to confine the dust away from the operator's face, a leather flap L is hinged so as to fall loosely over the top of the wheel. Below the wheel an inclined hopper H is fixed having a throat T which is inclined backwards from the operator and sideways in the direction of the fan so as to give a lead to the air current on entering the main duct D. The arrangement shown is of wood; but neater, less cumbersome and more serviceable fittings can be made of a similar design in metal with circular throat and tapered cylindrical duct for use with centrifugal fans. (*See* Plate XXIIa.)

PLATE XXII.

OTHER GRINDING.

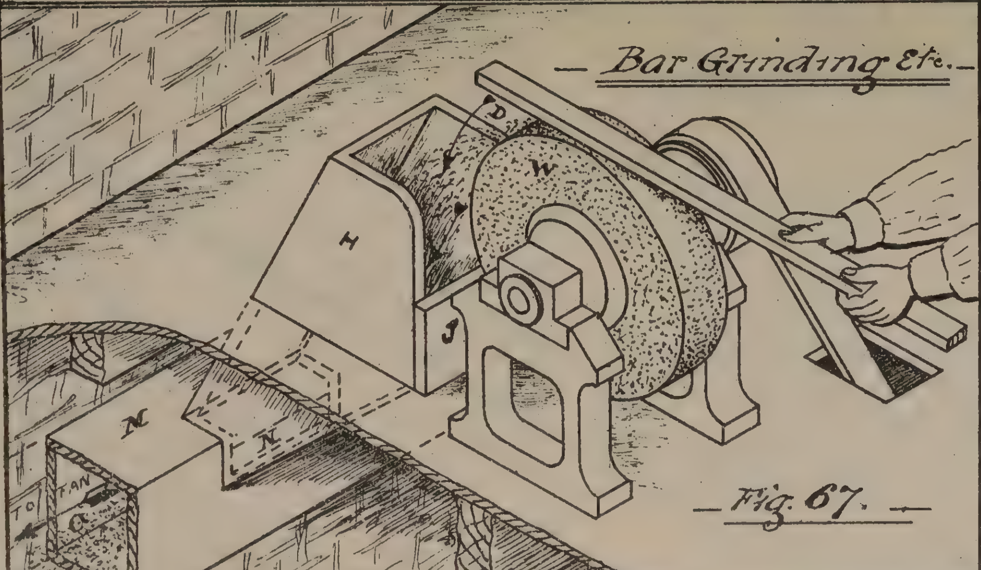
(*Drawings by the Secretary from sketches made in Rotherham (Messrs. Micklethwaite & Co.), Fig. 67; Sheffield, Fig. 68; and Worcester (Messrs. Fownes, Ltd.). Engineers: The Sturtevant Engineering Co., and The Standard Engineering Co., Ltd.*)

Another kind of grinding is illustrated in Fig. 67, where grinding of long pieces of metal requires use to be made of the top and sometimes the sides of a wheel W. In this case the wheel is fixed low towards the floor, and it is immediately confronted with the hopper I, the opening of which comes up close to the wheel, and the back is inclined towards the main duct at an angle which renders it suitable to receive the flow of dust indicated by the arrows. The board J is brought up as close as possible behind the wheel to act as a sort of scraper, and thus to prevent dust being carried round under the wheel by the film of air which follows the periphery. The neck of the hood N beneath the floor is inclined towards the fan on entering the main duct M for the same purpose as described in the last case (Fig. 65). Fig. 68 shows a typical fork grinder at work. In an attitude half bent over the wheel, which travels over and away from him, he has the dust removed by a hood fitted to the back of his wheel, with a passage O beneath it which leads to the exhaust fan (or "Fanny" as it is locally known.) Goggles G are worn for the preservation of his eyesight. The arrangement is crude, and probably wasteful of fan power, but the peculiar conditions of tenancy and hired fan-power under which this work is carried on renders improvement slow of attainment. Although unconnected with the processes of dry grinding, the subject of Fig. 69 necessitates an arrangement somewhat similar in character to that described by Fig. 67, and is therefore touched on at this point. The process alluded to is that of "stoning" hides in the skin-dressing trade, by which is meant the removal of coarse uneven particles from the underside of skins intended for gloves and upper making. This is done on coarse emery wheels of the shape shown at B, and the dust given off is of a light fluffy nature, which hangs about the room and festoons on everything. In the arrangement shown, each wheel is surrounded by a box A with a flat top—which, in the case of a series, extends from wheel to wheel to form a continual bench. Immediately at the back of the wheel a hopper with three inclined surfaces H is sunk in to receive the dust as it flies from the wheel; from this hopper the dust is sucked downwards in the direction of the arrow to a bell-mouth *c*, forming the entrance to a curved down pipe C which strikes into the main duct D at an angle sufficiently inclined towards the fan to facilitate the flow of dust into the main stream. Between the back part of the wheel B and the bell-mouth *c*, a shield or scraper *x* is interposed to prevent any dust being carried round the wheel and up again, so that every particle shall find its way into the main duct. The dust which is so far successfully removed by this method is somewhat difficult to collect and deposit in its dry state; and the dust chamber, therefore, requires to be fitted with a steam jet or water spray to prevent any escaping with the spent current of air from the deposit house.

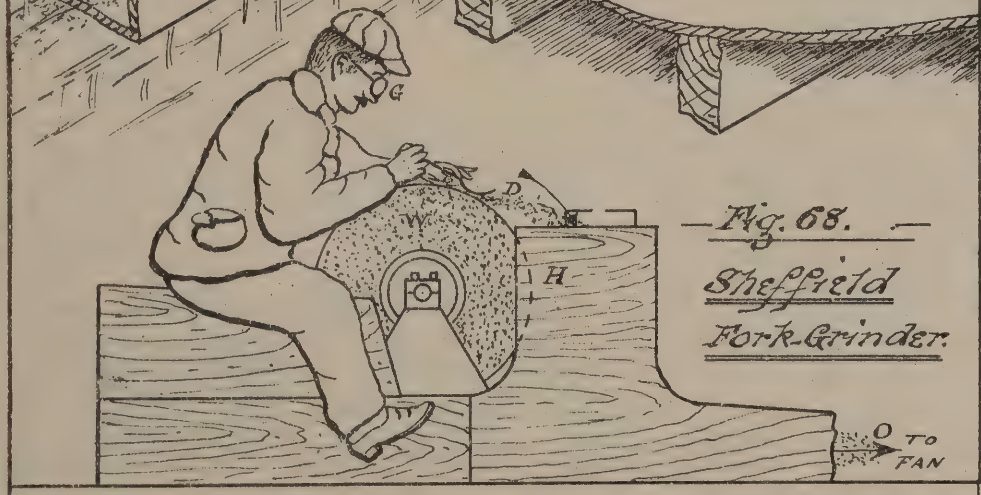
PLATE XXII.

Three Instances of Dust Extraction by Down-draught in Dry Over-wheel Grinding Processes.

— Bar Grinding Etc. —

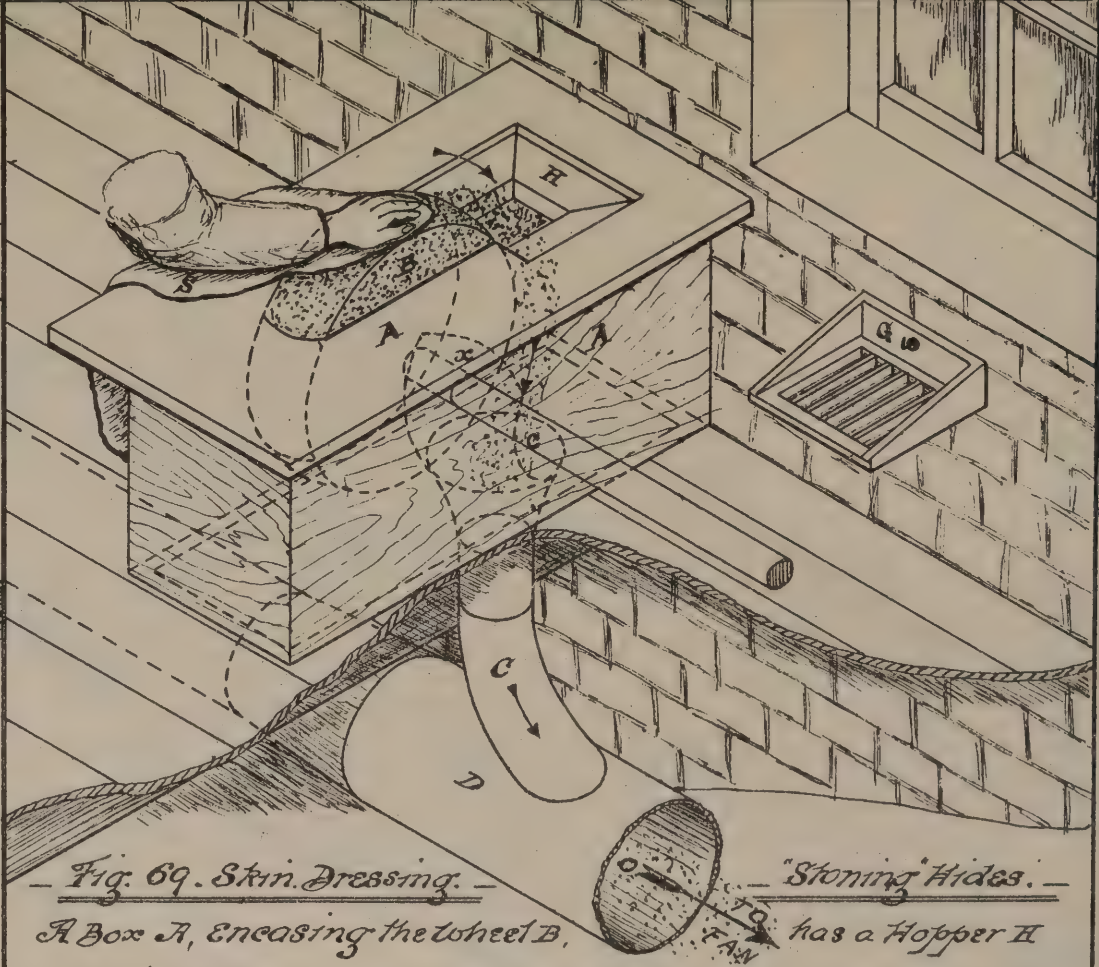


— Fig. 67. —



— Fig. 68. —

Sheffield Fork-Grinder.



— Fig. 69. Skin Dressing. — "Stoning" Hides. —

A Box A, Encasing the wheel B, has a Hopper H vertically over a Downspout C which conveys Dust to Main Trunk D. — A Grid, G, fits over the Hopper H when necessary.

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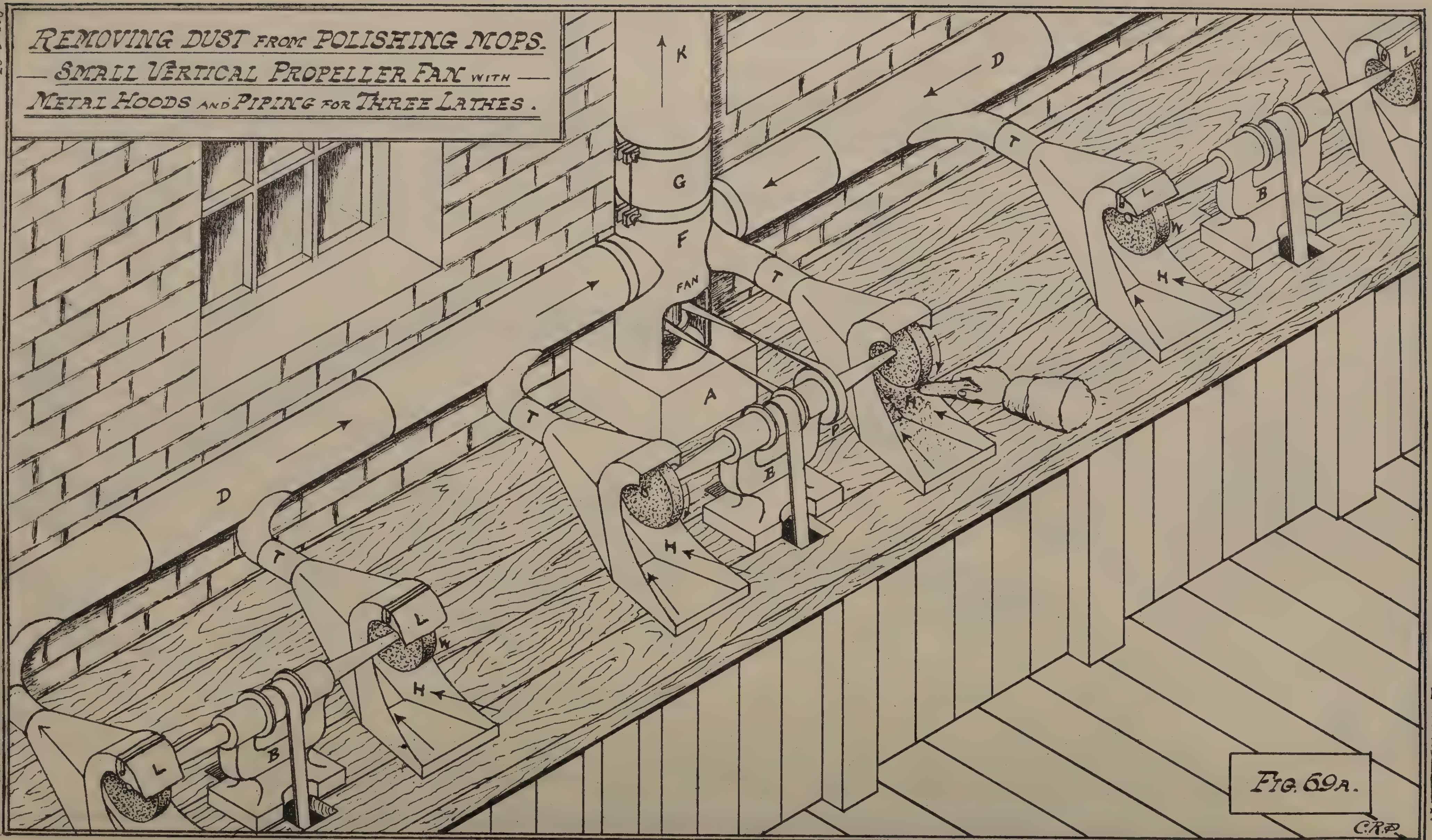
PLATE XXII A.



REMOVING DUST FROM POLISHING MOPS.

— SMALL VERTICAL PROPELLER FAN WITH —

METAL HOODS AND PIPING FOR THREE LATHES.

FIG. 69A.

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PLATE XXIIA.

METAL POLISHING—SMALL POWER FAN, ETC.

(*Drawing made by the Secretary from sketches and photographs furnished by the Engineers, Messrs. Foster, Dyson & Co.*, 51, *Moseley Street, Birmingham.*)

In this plate is shown a new arrangement which seems particularly well adapted for use in connection with the smaller polishing lathes which are used in the Bright Metal Trades, particularly in Birmingham. It will be seen that the fan F is placed on the bench immediately behind the head-stock of a polishing lathe—one of a set of six—and is driven from a pulley P on the spindle of that lathe by means of a short half-crossed $\frac{3}{4}$-inch leather belt. The fan is of a two-bladed archimedean propeller type, which has recently been patented by the makers (Messrs. Foster & Dyson). The axle of the fan is placed vertically, and the delivery tube K is a continuation of the fan casing F. Between K and F, however, there is a small tubular section G made in two halves and fastened with clips so that it can be rapidly removed and the whole fan got at inside for cleaning, a frequently necessary operation in this class of work. The fan in this case, one of 10-inch diameter, is of very simple construction and extremely light running, as evidenced by the fact that it is driven by a very short $\frac{3}{4}$-inch belt. It is made to run at a high velocity, however, and generates a very strong suction current in the main duct D D, which is communicated to the hoods H H by means of the throats T T. The hoods H H are of the slipper-shape shown, and can be varied to meet almost all conditions of work. In some cases a flap of leather or brown paper L is strapped to the upper part of the hood in a way that assists the object of dust prevention without interfering with the work of the polisher. The dust discharged by the fan can either be blown out through the nearest window or carried to a suitable separator in any convenient part of the factory. The system is quite new in many of its features, but has already given great satisfaction where it has been tried.

PLATE XXIII.

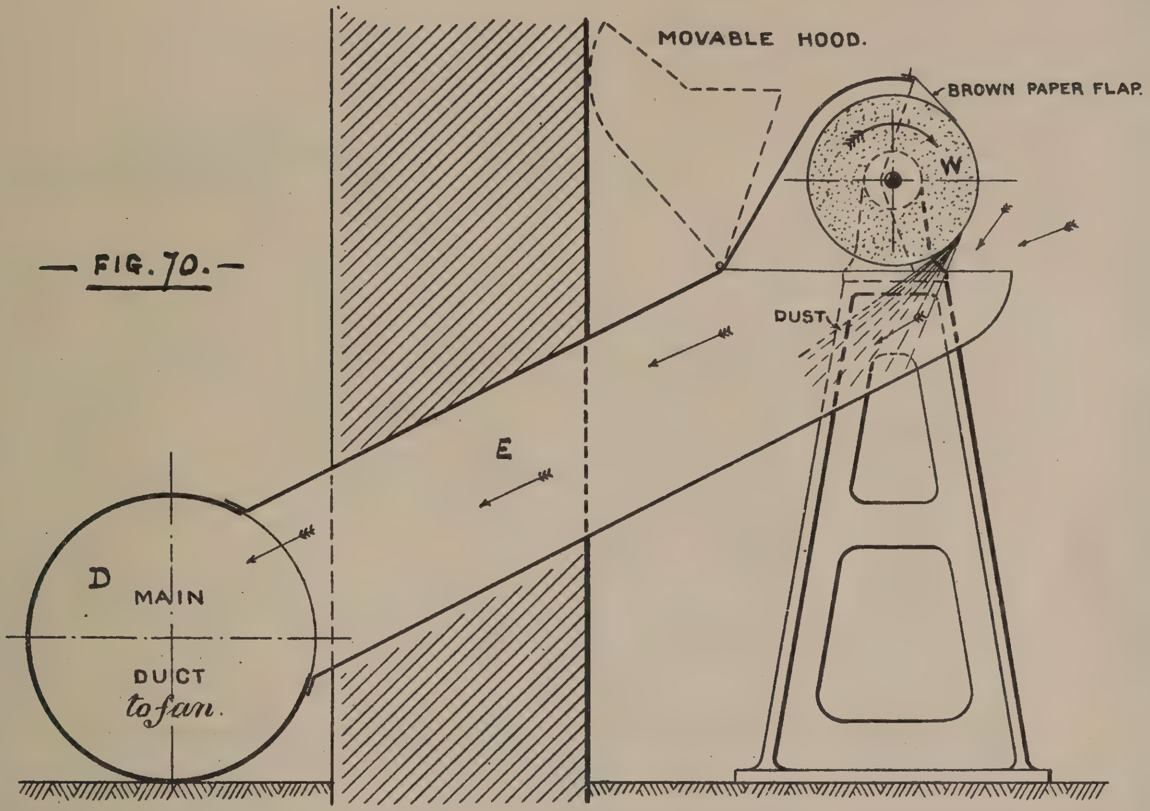
METAL POLISHING.

(*Drawings submitted by Messrs. The Jas. Keith and Blackman Company, Limited, London.*)

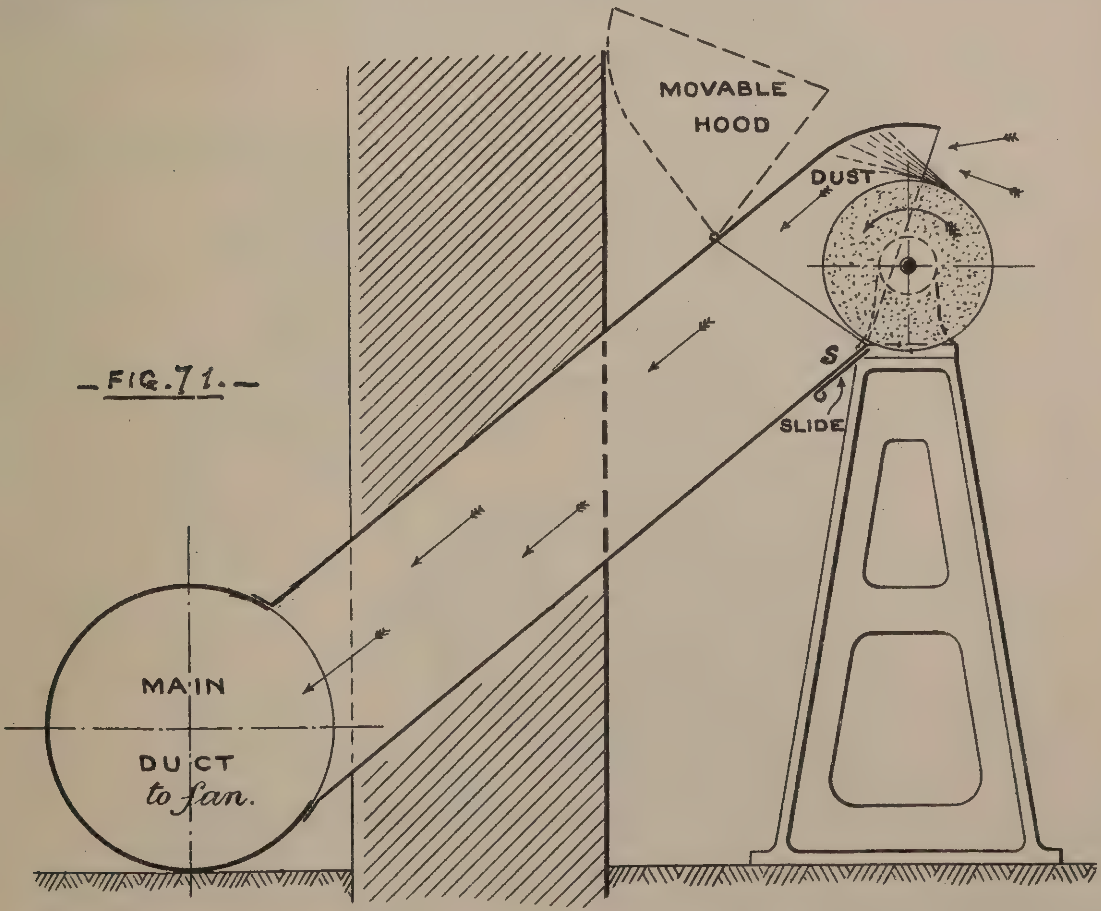
Fig. 70 shows an arrangement of hood, down-pipe and main duct for use with a propeller fan for exhausting dust from polishing lathe on independent standard. In this case the exposed part of the wheel is shown to be travelling downwards as indicated by the arrows and sparks.

Fig. 71 shows an outline arrangement of similar character for a wheel running in the *reverse* direction. Notice the slide S immediately under the wheel to close up any opening caused by wear. In each of the above cases sheet metal is used for the parts.

REMOVING DUST FROM BOBS AND MOPS.



— FIG. 70. —



— FIG. 71. —

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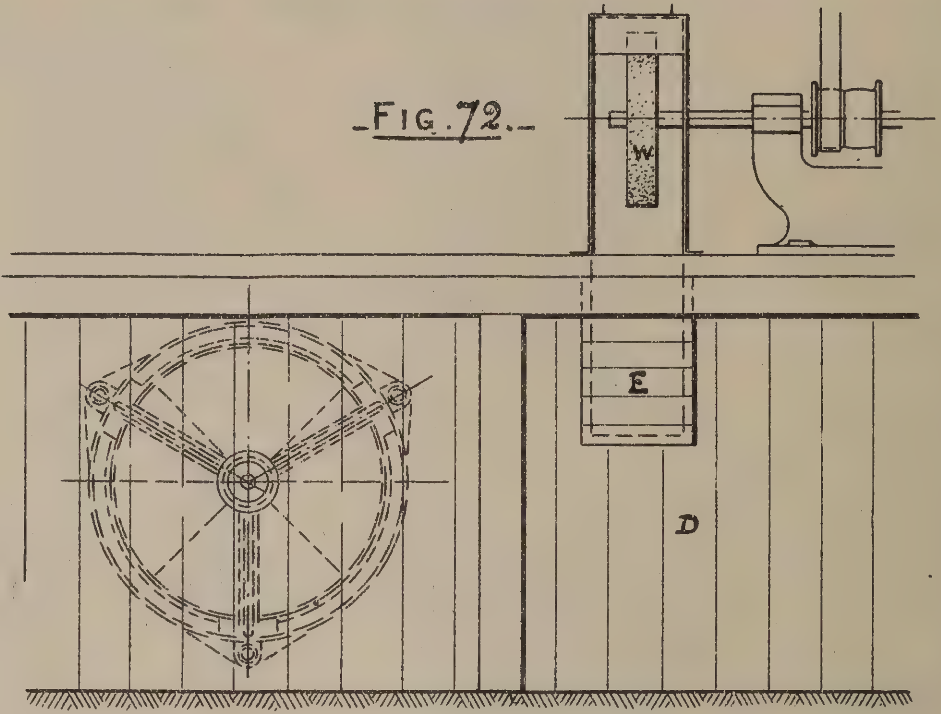
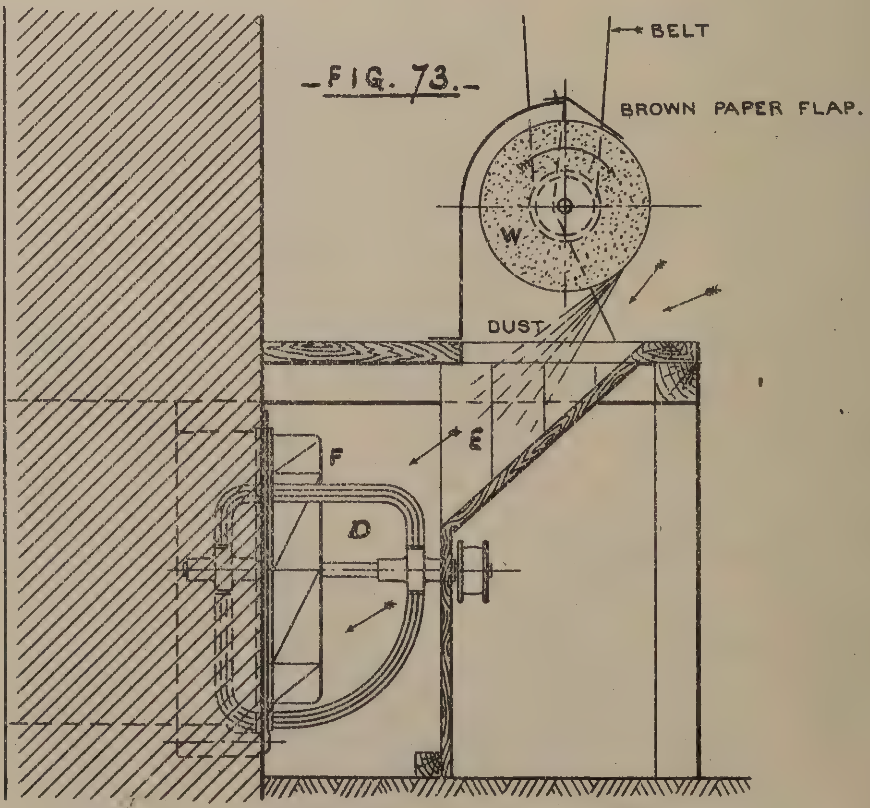
REMOVING DUST FROM BOBS AND MOPS

FIG. 72.



ELEVATION

FIG. 73.



SECTION

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PLATE XXIV.

METAL POLISHING.—(*continued.*)

(*Drawings submitted by Messrs. The J. Keith & Blackman Company, Limited, Engineers.*)

Fig. 72 shows an outline elevation of a polishing bob fitted on a bench instead of an independent standard, the hood being of metal and the main duct and throat of woodwork, all comprised in the space covered by the bench itself. Fig. 73 shows by cross section how the dust is drawn towards the fan, the wheel rotating outwards and downwards as indicated by the arrow and the sparks. It will be noticed in the foregoing examples that no attempt is made to draw the dust backwards horizontally ; it is allowed to continue its downward course through the inclined shutes E E, a plan that generally gives the best results when the necessary passages can be cut through the bench.

PLATE XXV.

METAL POLISHING.—(*continued.*)

(*Drawings submitted by Messrs. The J. Keith & Blackman Company, Limited, Engineers.*)

The foregoing systems are applicable only where a bench already exists or can be fitted up without encroaching too greatly on the space of the room. In Fig. 74, however, an arrangement is shown for removing dust from wheels on independent standards, the fittings of which take up but very little room. The main duct is entirely below the floor, and the down pipes terminate at the top in hoods which can be swivelled to any position. The hoods, moreover, are hinged in such a way that they can be arranged to receive the dust from a wheel travelling either way ; compare Fig. 74 with Fig. 75.

Fig. 76 shows an arrangement somewhat similar to Fig. 71 adapted specially for polishing long rods such as K, which are passed under the wheel and right through the exhaust duct E, which is provided with a hole H and flap F at the back for the purpose.

REMOVING DUST FROM BOBS AND MOPS.

FIG. 74. FIG. 75.

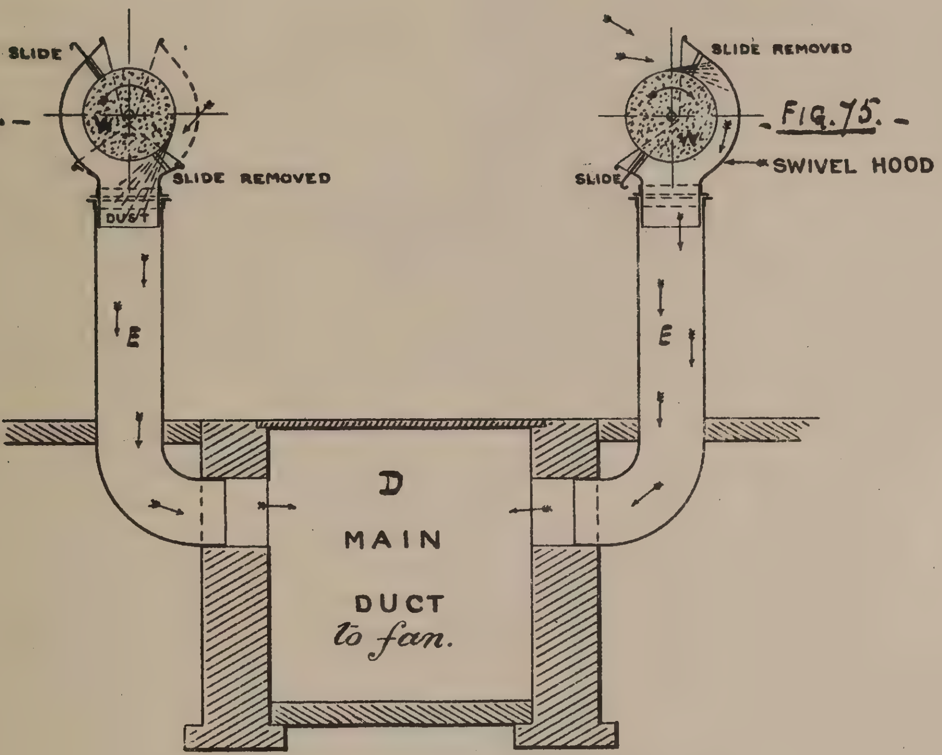
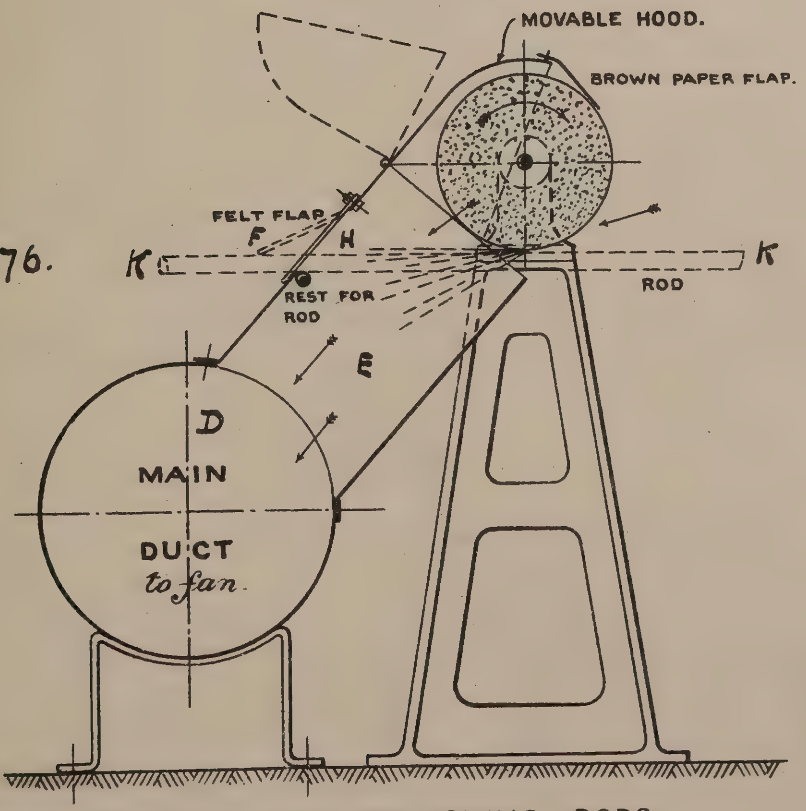


FIG 76.



ARRANGEMENT FOR POLISHING RODS

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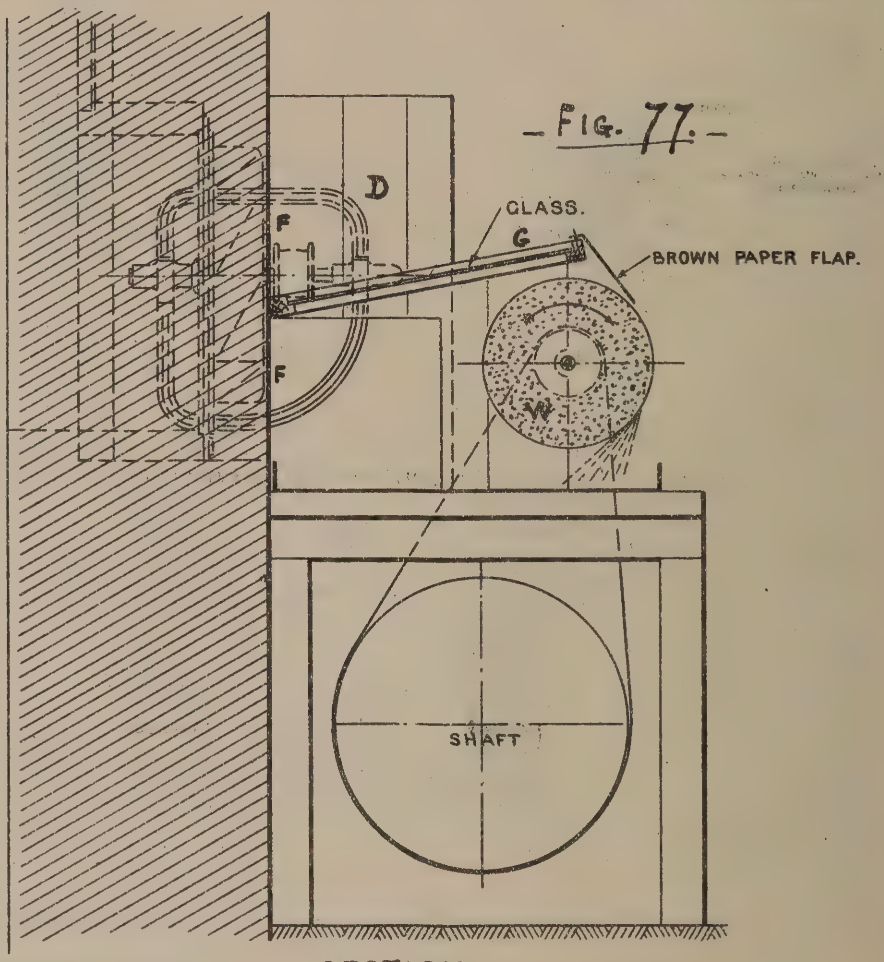
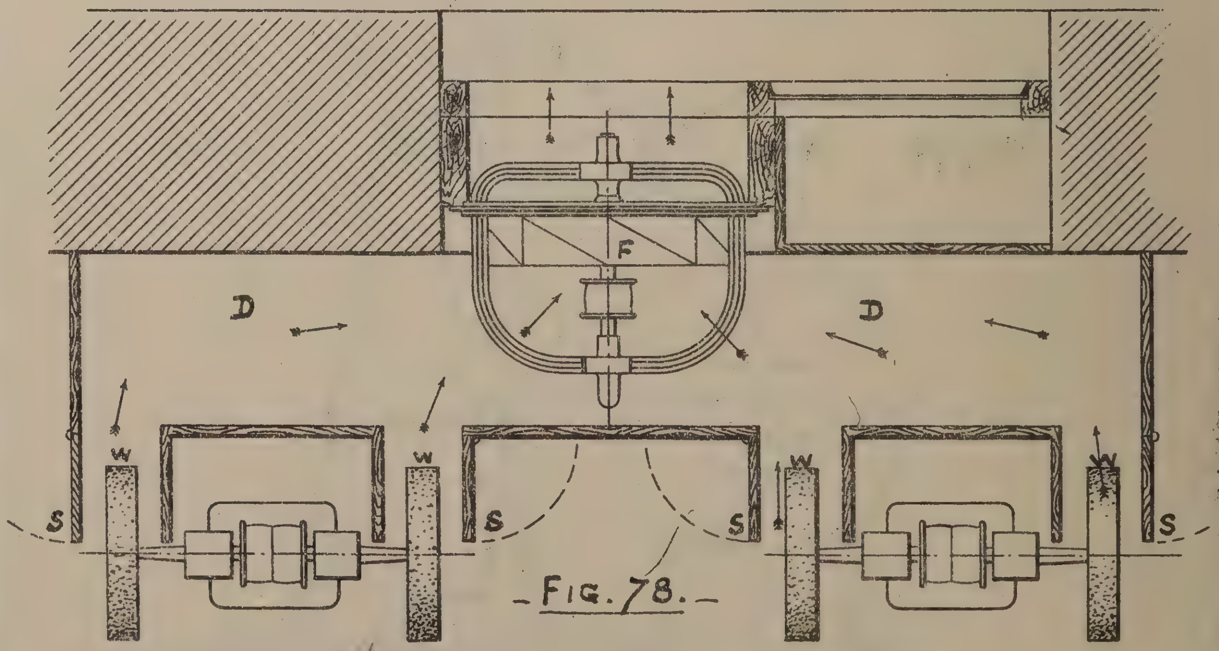
REMOVING DUST FROM BOBS AND MOPS.



- Fig. 77. -

SECTION



- Fig. 78. -

PLAN

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PLATE XXVI.

Metal Polishing.—(*continued.*)

(*Drawings submitted by Messrs. The J. Keith & Blackman Company, Limited, Engineers.*)

Fig. 77 shows an arrangement in which the fan is placed above the bench and immediately at the back of a glazed hood which is sufficiently large to take in two sets of wheels (*see* Section in Fig. 78). This does away with the necessity for branch ducts or throats. It should be noted that the sides S S S S are all made to hinge back to permit of changing the wheels. The bench itself is covered with a metal tray beneath the hood, which facilitates cleaning, &c., but has the disadvantage of providing each hood with a flat bottom instead of the preferable slanting chute as E E in Plates XXIII. and XXIV.

Speaking generally, the use of propeller fans and accompanying large sized ducts and air guides, is too wasteful of space for adoption in works where many machines are used, and their multiplication would take up room that can be put to more valuable use.

Neat metal hoods of the "Slipper" pattern with cylindrical ducts placed underground or out of sight can generally be used to much better effect.

PLATE XXVII.

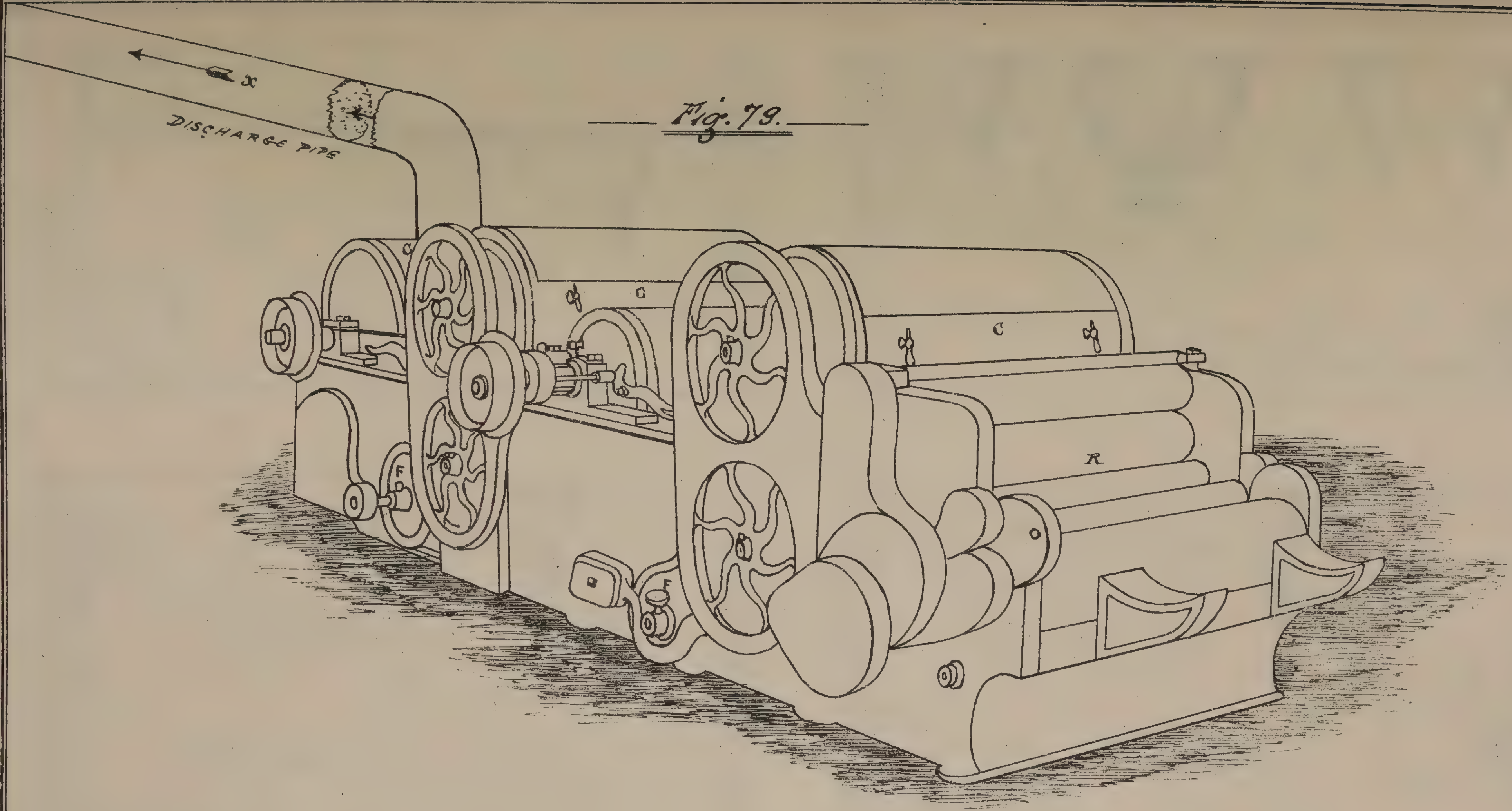
TEXTILE DUSTS.

(*Drawing by the Secretary from photograph by Messrs. Platt Brothers, Limited, Oldham, Engineers.*)

The removal of dust from textile manufacturing processes has for long commanded the interest and attention of ventilating engineers. In some processes, especially the earlier processes of opening, roughing and sorting, &c., it can be dealt with fairly well because the machines themselves are capable of being almost entirely enclosed. A good instance of this is the exhaust cotton opener as shown in Fig. 79. This machine is so completely covered as to be practically dust-proof, and fans at F F revolving at a high rate of speed are contained in the machine to draw off the dust and to discharge it in the direction of the arrow X towards a proper retaining receptacle.

PLATE XXVII.

Fig. 79.



Enclosed Dusty Machines with Self-contained Fans. — Exhaust Cotton-Opener.

C.R.P.

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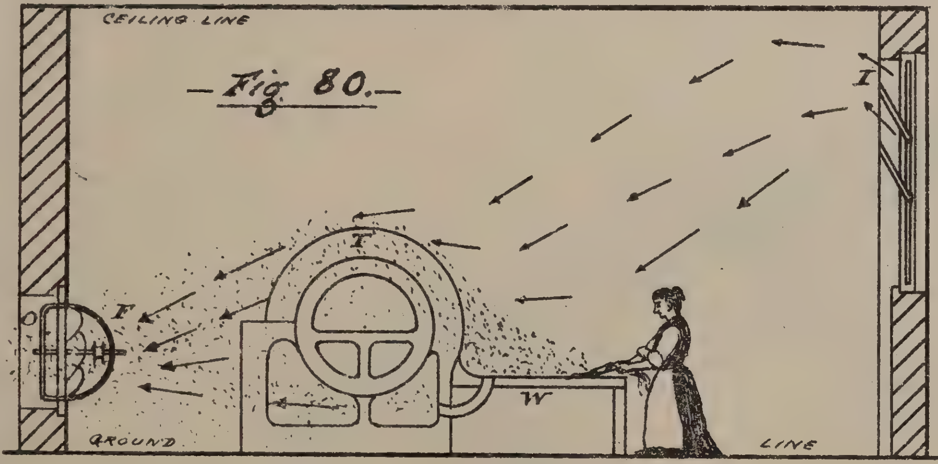
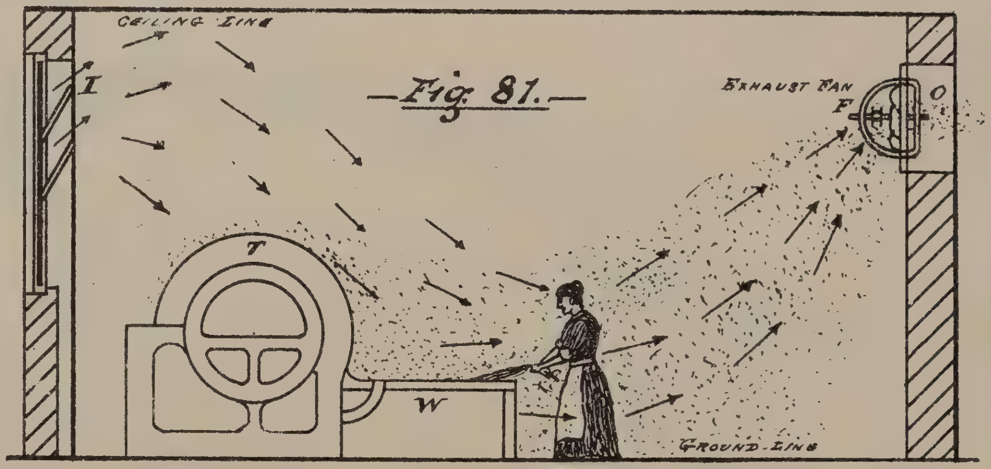
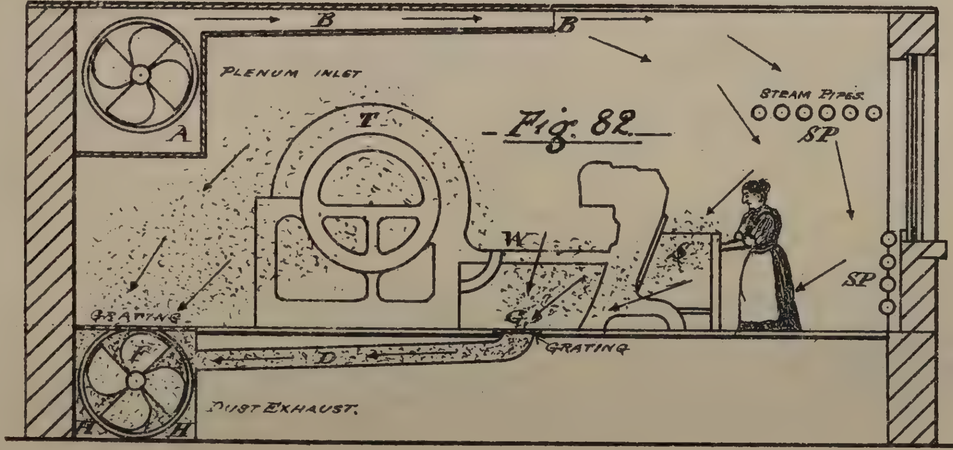
— Good and Bad Arrangements for Removing Dust etc: from Breathing Level by Propeller Fans. —



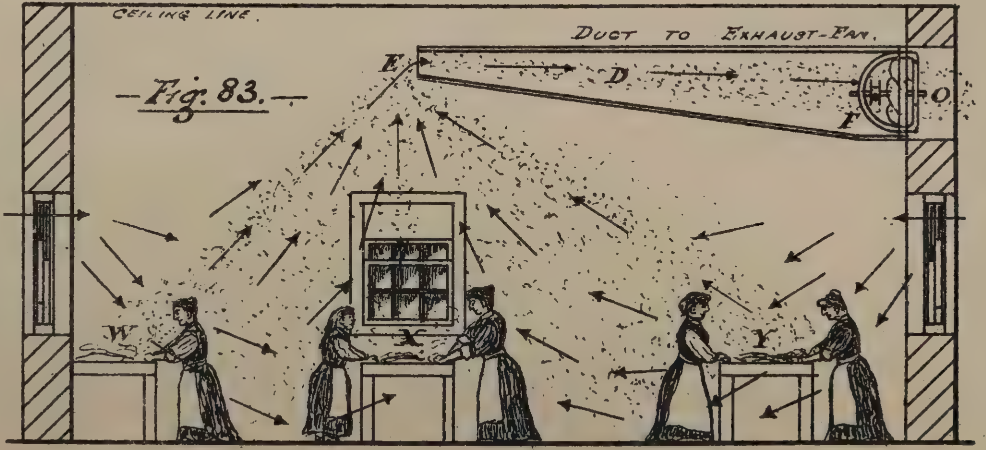
-Fig. 80.-



-Fig. 81.-



-Fig. 82.-



-Fig. 83.-

C.A.P.

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PLATE XXVIII.

Textile Dusts.—(*continued.*)

(*Diagrams drawn by the Secretary from sketches by Dr. J. S. Haldane, and Mr. E. H. Osborn, also Fig. 82 from system in use by Messrs. J. and T. M. Greeves, Limited, Belfast.*)

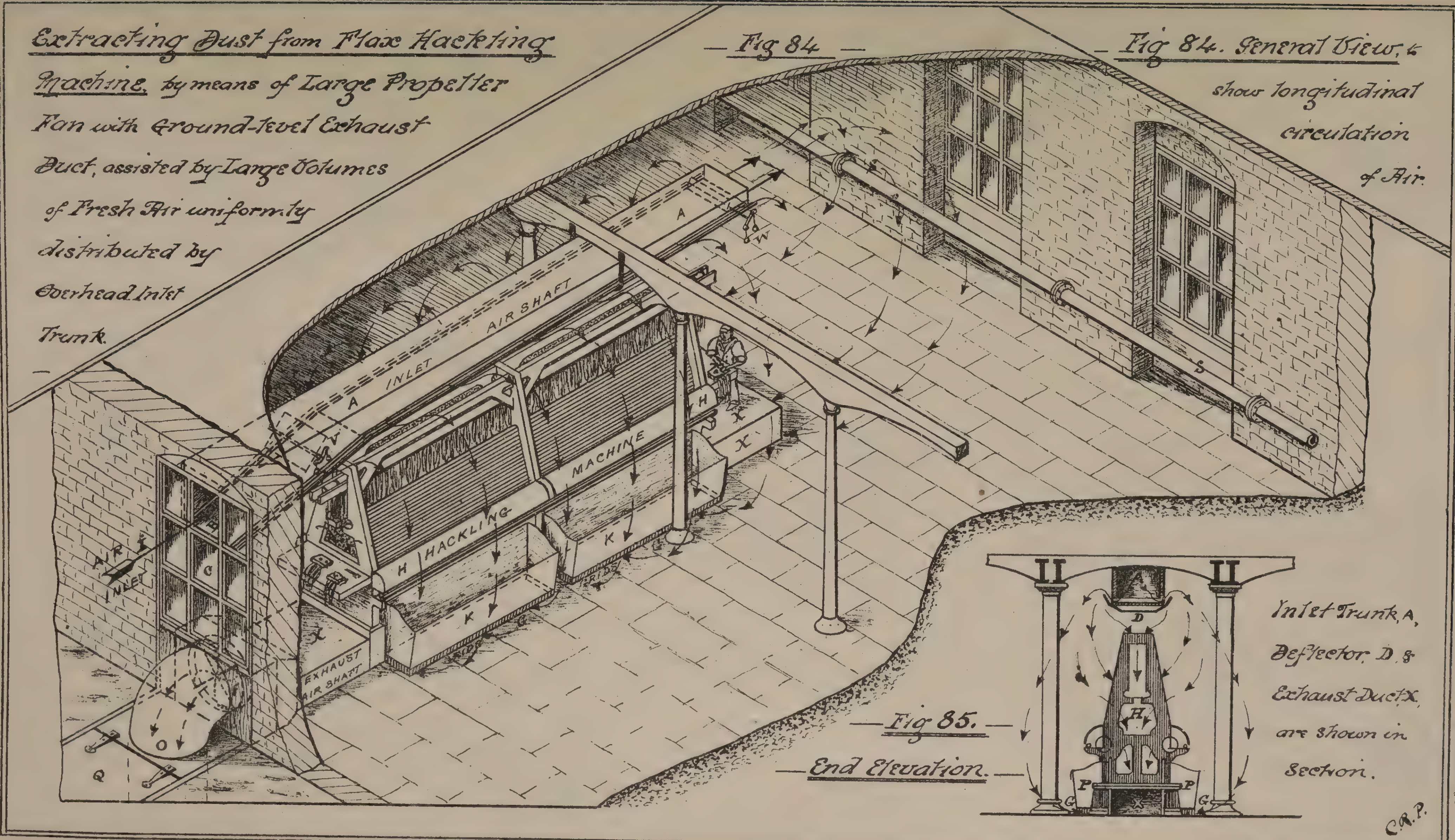
Far more difficult is the satisfactory removal of dust from machines that cannot be so easily and thoroughly cased in ; and especially so when open fans have to be employed to combine the process of dust removal with general ventilation. Take, for instance, the machine shown in Fig. 81, where dust is generated on a feeding table W, and given off from various other parts of the machine. An ill-considered attempt to remove the dust has been made by placing the fan in an entirely wrong position, *i.e.*, a position in which the dusty machine is between the inlet and the worker, and the worker herself between the dust and the fan which is supposed to extract it. Here the deflectors at the inlet I will cause the air to ascend ceilingwards and descend as shown by the arrows ; and the dust caught by the downward current will be prevented from rising or falling, but will be carried in a stream right past the worker's face as indicated by the arrows, thus increasing the evil which it is intended to avoid. In Fig. 80 a more sensible arrangement is shown. The dusty machine is between the worker and the fan F ; the window inlet I supplies the worker with fresh air, at the same time carrying away under the influence of fan F the dust which would otherwise hover about in her vicinity. Although a much better system than the last, it cannot be regarded as perfect, as the air currents are liable to accidental interference due to the opening or shutting of windows and difference in temperature, &c. A great but somewhat expensive improvement on the last system is shown in Fig. 82, which is a diagram of the arrangement devised by Mr. Eves, for Messrs. J. and T. M. Greeves, Limited, of Belfast, for ventilating a flax carding room. Under this system open windows are dispensed with and a definite supply of air is driven in by a powerful fan A which distributes it along the whole length of the ceiling through the plenum inlet B, and the air being forced in the direction of the arrows past the steam pipes S P, a comfortable temperature in cold weather is ensured. The current of air coming thus fresh to the worker is drawn onwards towards the grating G under the influence of an exhaust fan F, and the dust is drawn downwards and backwards to a position much less harmful than when surrounding the attendant. Fig. 83 shows an attempt to remove dust by means of a propeller fan and exhaust duct brought to nearly the middle of the room. As the point of exhaust at E is the same as though the fan itself were there, the dust is drawn upwards to that point in a way that either keeps it unnecessarily in suspension or actually takes it past the workers' faces.

PLATE XXIX.

TEXTILE DUSTS.—FLAX HACKLING BY MACHINE.

(*Method of Ventilation adopted by Messrs. J. & T. M. Greeves, Ld., Belfast, from designs by Mr. Eves. Drawn by the Secretary.*)

A capital instance of ventilating a large open textile machine by means of properly directed air circulation, is that shown in Fig. 84. It represents another installation for which the Committee are indebted to Messrs. Greeves, Ld., Belfast. The machine itself is used for hackling flax, and is one of considerable size. The two leading features of the system are the long inlet air shaft AA, which extends from the outside window to a point above and beyond the machine, and the return exhaust trunk XX which extends the whole length beneath the framework of the machine and terminates in a powerful exhaust fan F, which discharges the dust-laden air into a pit outside. The fan F, in drawing the air from the room in this manner, sets up a partial vacuum which can only be satisfied by air which enters at the inlet I, passes through the removed pane B, and thence through the air shaft and distributor AA. On each side of this air shaft AA is a slot by means of which air escapes over a deflector D at all points in its length (*see* section Fig. 85): the air thus escaping is afterwards drawn down towards the floor by the influence of the exhaust fan F and its duct XX, so that continuous downward air currents are sent out in all directions as indicated by the arrows. At the end of the duct X and at its sides (beneath the boxes KK) the dust-laden air is drawn through grids, and in order to better accomplish this purpose each machine has its normal foundation raised by several inches on to a pedestal PP, thus forming the duct X beneath (*see* section Fig. 85). The proportion of incoming air can be regulated at the beginning and end of the trunk A by means of throttle valves V and W respectively; and the main volume of inflowing air can be passed over steam pipes at S to slightly raise its temperature when necessary.



Extracting Dust from Flax Hackling Machine, by means of Large Propeller Fan with Ground-level Exhaust Duct, assisted by Large Volumes of Fresh Air uniformly distributed by Overhead Inlet Trunk.

— Fig 84 —

— Fig 84. General View, to show longitudinal circulation of Air.

— Fig 85. —

— End Elevation. —

Inlet Trunk, A, Deflector, D, & Exhaust Duct, X, are shown in Section.

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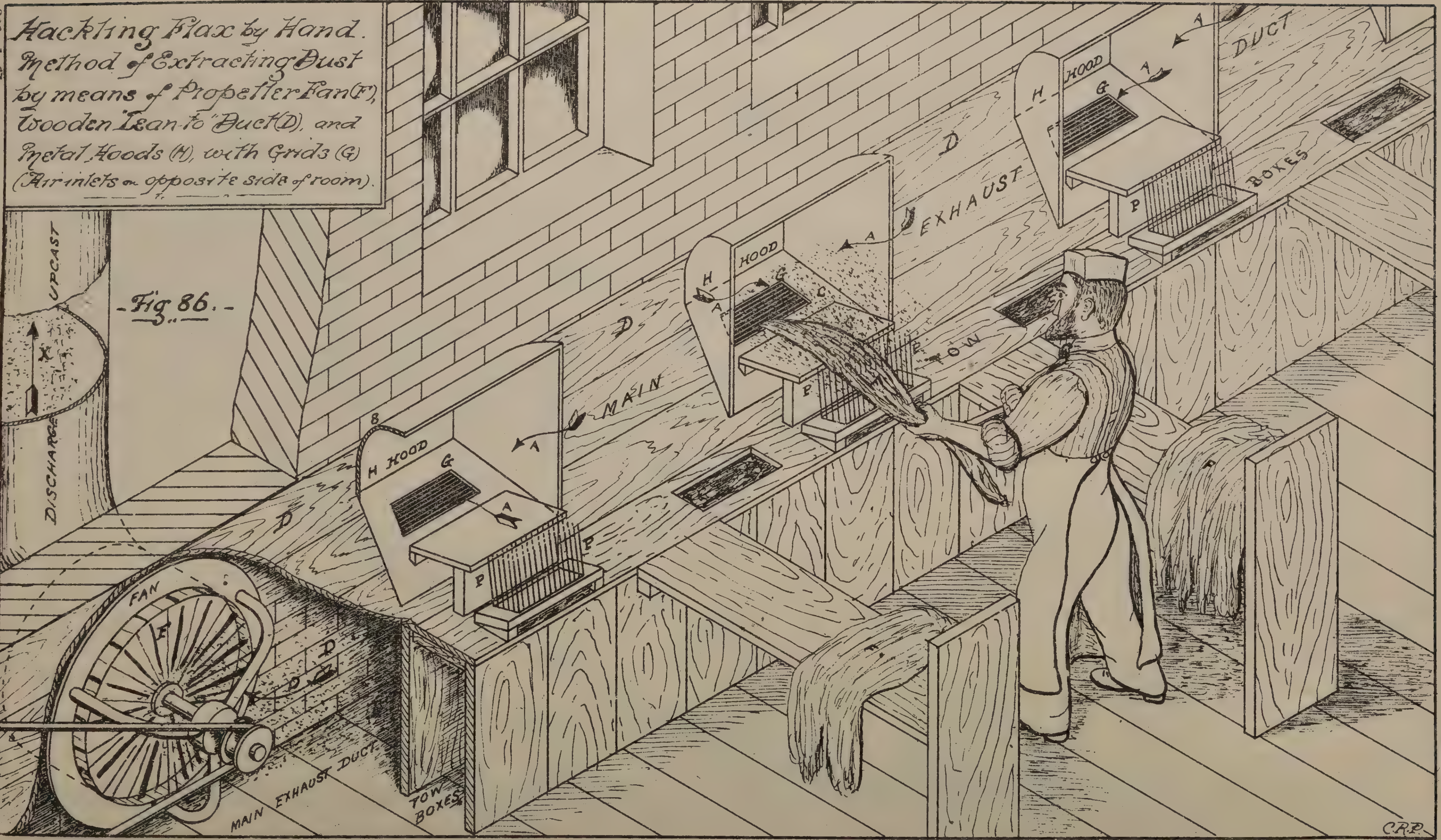
PLATE XXX.



Hackling Flax by Hand.
Method of Extracting Dust
by means of Propeller Fan (F),
Wooden "Lean-to" Duct (D), and
Metal Hoods (H), with Grids (G)
(Air inlets on opposite side of room).

-Fig. 86.-

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PLATE XXX.

TEXTILE DUSTS.—HAND HACKLING.

(*Drawn by the Secretary from system in use by Messrs. The York Street Flax Spinning and Weaving Company, Belfast*).

Another process in the flax industry which gives much trouble is that of hackling flax by hand, and the operation is illustrated in Fig. 86. The operator, taking a wisp of flax F in his hand, forcibly draws it across the comb of hackle pins PP, at the same time forcibly striking it on the small platform C, causing dust to be given off in considerable quantities. This dust is highly injurious and has generally to be drawn away by fan power. In this case the system is to have a hood H of the shape shown immediately in front of the worker's comb. At the base of this hood is a grid G through which dust is drawn in the direction of the arrows A downwards into a main exhaust duct DD, which in its turn leads towards a powerful propeller fan F, and from thence to a properly arranged discharge. The duct itself is simply placed between the wall and the row of tow boxes and covered in by a lean-to wooden roof as shown.

In a still more effective example a supply of fresh air was brought in from the outside through an overhead duct to inlet pipes at the back of each worker, and these inlets being curved in such a way as to throw a well-directed blast of air over the dustiest place and towards the exhaust gratings, the worker was doubly benefited by the direct supply of untainted fresh air for breathing and by the immediate removal of dust from before his face. (*See* Plate XXXI.)

PLATE XXXI.

TEXTILE DUSTS.—HAND HACKLING.

(*Drawn by the Secretary from system in use by Messrs. J. and T. M. Greeves, Belfast, designed by Mr. Eves.*)

In one of the best and largest installations seen by the Committee a double deck arrangement was used, the space between the upper and lower levels serving as a main duct communicating all the exhaust openings to a powerful fan at each end of the room.

A cross section of this arrangement is shown in Fig. 87, Plate XXXI., and a comprehensive general view is given in Fig. 88 on Plate XXXII.

In Fig. 87 it is more clearly shown how the exhausted space or main duct XX between the upper and lower deck is directly connected to the fan Z on the one hand, and on the other hand to various downlets P, D, Y, O, N, each of the latter terminating in an air guide or hood suited to its special purpose, as at F, C, Y, L, M.

The hoods F and Z are placed nearly opposite to the comb of hackle pins E, and are faced with wire gratings to prevent wisps of flax being sucked into the downlets O P when the fan is in operation to draw dust from the worker's face.

The downlets A and N have entrances C and M, which form part of a continuous trough just immediately under the front edge of the bench, so as to receive such dust and stray fibres as are given off below the strick of flax which is being hackled.

The hopper and downspout Y receives and draws downward the dust given off when the hackler gives the flax a flick behind him, as is frequently necessary when poising the strick for another throw across the hackle pins.

The foregoing details are connected with the exhaust part of the system only ; but inasmuch as these large fans are capable of extracting a minimum volume of 275 cubic feet per worker per minute, and a large number of hacklers are employed in the room, the inlets have to be arranged with the same care as the exhaust outlets, otherwise the latter would be unequally effective and vexatious draughts would be set up by the enormous quantity of air passing through the body of the room.

Herein was an opportunity for the engineer to so arrange the inlet and distribution of fresh air as to promote the general ventilation of the building whilst greatly aiding the work of dust removal ; in other words to give each man a direct supply of pure air above and behind him, and at the same time withdraw all dust from in front of and below him. This object was achieved by having a main air shaft H placed under the ceiling and extending all along on that side of the room, remote from the windows and adjoining a blank wall. From the under side of this main air shaft two distinct pipes I and J were extended downwards to a suitable position with regard to each table and workplace, the pipe I being curved upwards to the right-by-rear of each worker, and the pipe J carried below the table to rise again perpendicularly at the right-by-front of the same man. The effect of this setting is roughly indicated by the arrows, the air losing the force of its first inrush in an upward progress to the ceiling, thence to diffuse and surround the worker with gentle, weakened. and imperceptible currents, which, after supplying him with fresh air, soon come within the direct influence of the fans, and as they draw nearer the air guides F, C, Y, L, M, are re-formed into rapidly accelerating exhaust currents, and so pass out through the fans laden with dust accumulated during their circuit.

It should clearly be noted that the incoming air is not *blown in* through through the air shaft H, but in reality is *sucked in* by the operation of the fans Z Z ; for these powerful fans, having to derive all their supply of air from that in the room, tend to set up a partial vacuum, which can only be satisfied by means of inlets of corresponding capacity ; and inasmuch as the inlets are purposely restricted to the channels above described, all the air entering the building can be controlled in amount and steered in direction. The dirigible currents thus set up are made good use of at points where the dust is thickest—as above and behind the comb E for instance. The dust that would otherwise ascend and mingle with the general air is immediately caught by a definite blast of air from the spout G, which at once carries it across to the grating F, then to be swept away by the exhaust current through P to X and Z. This use of a dirigible blast in conjunction with a local exhaust appears to be highly successful ; a success that suggests a wide field of utility in other directions.

It will be noticed that for the supply of air to those near an external wall the air can be brought in either direct from the outside on the Tobin-tube principle (see arrows in pipe A) or through a shaft fitted with a tempering coil as at H.

The window inlets (B) can be held in reserve for the warmest weather, and even then should only be used where short circuiting can be avoided.

PLATE XXXI.

—COMBINED LOCAL AND GENERAL VENTILATION IN FLAX HACKLING SHOPS.—

—SECTIONAL DIAGRAM.—

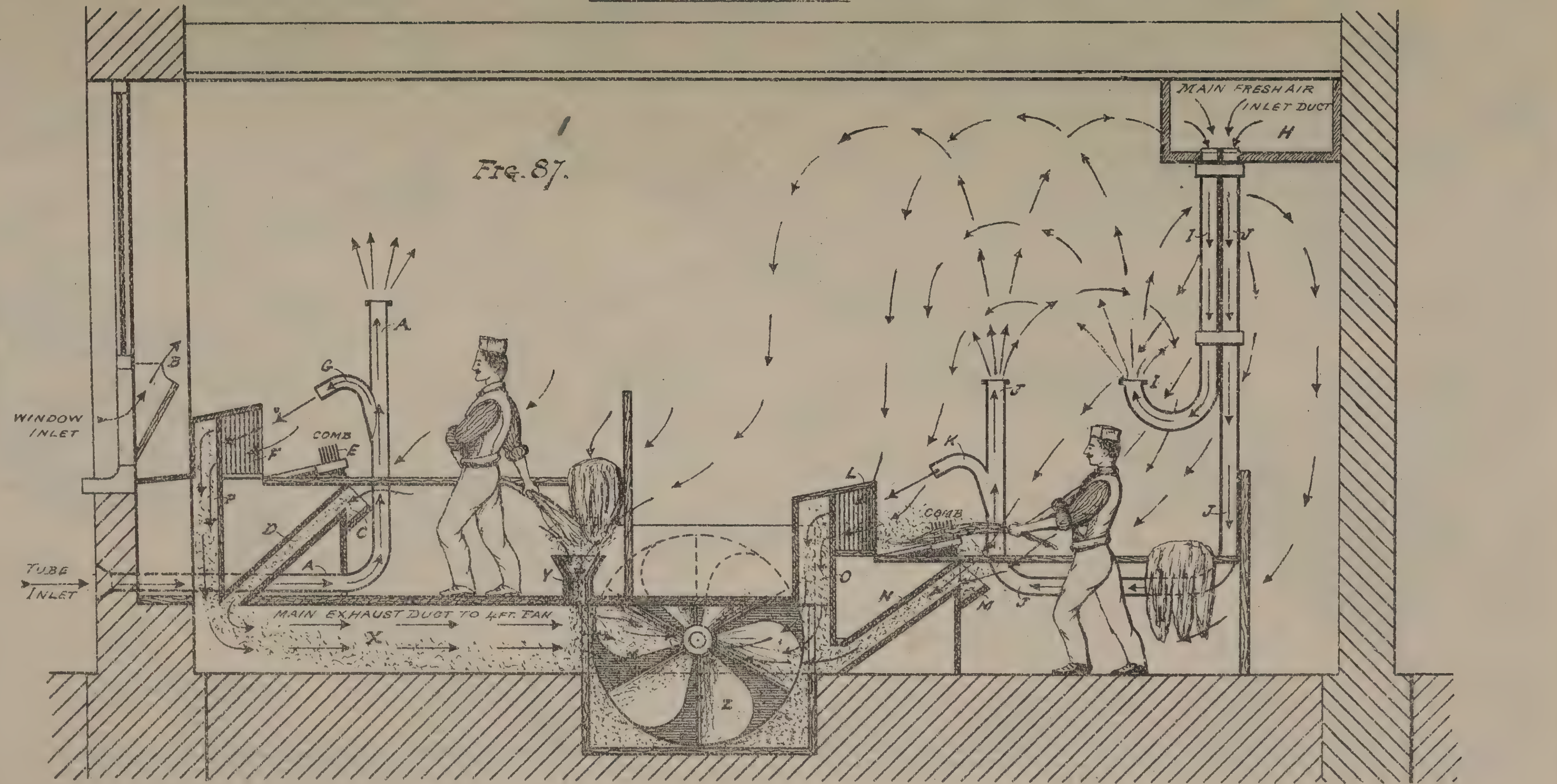

Fig. 87.

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—DUST EXTRACTION BY EXHAUST ASSISTED BY DIRIGIBLE INLET AIR CURRENTS.—

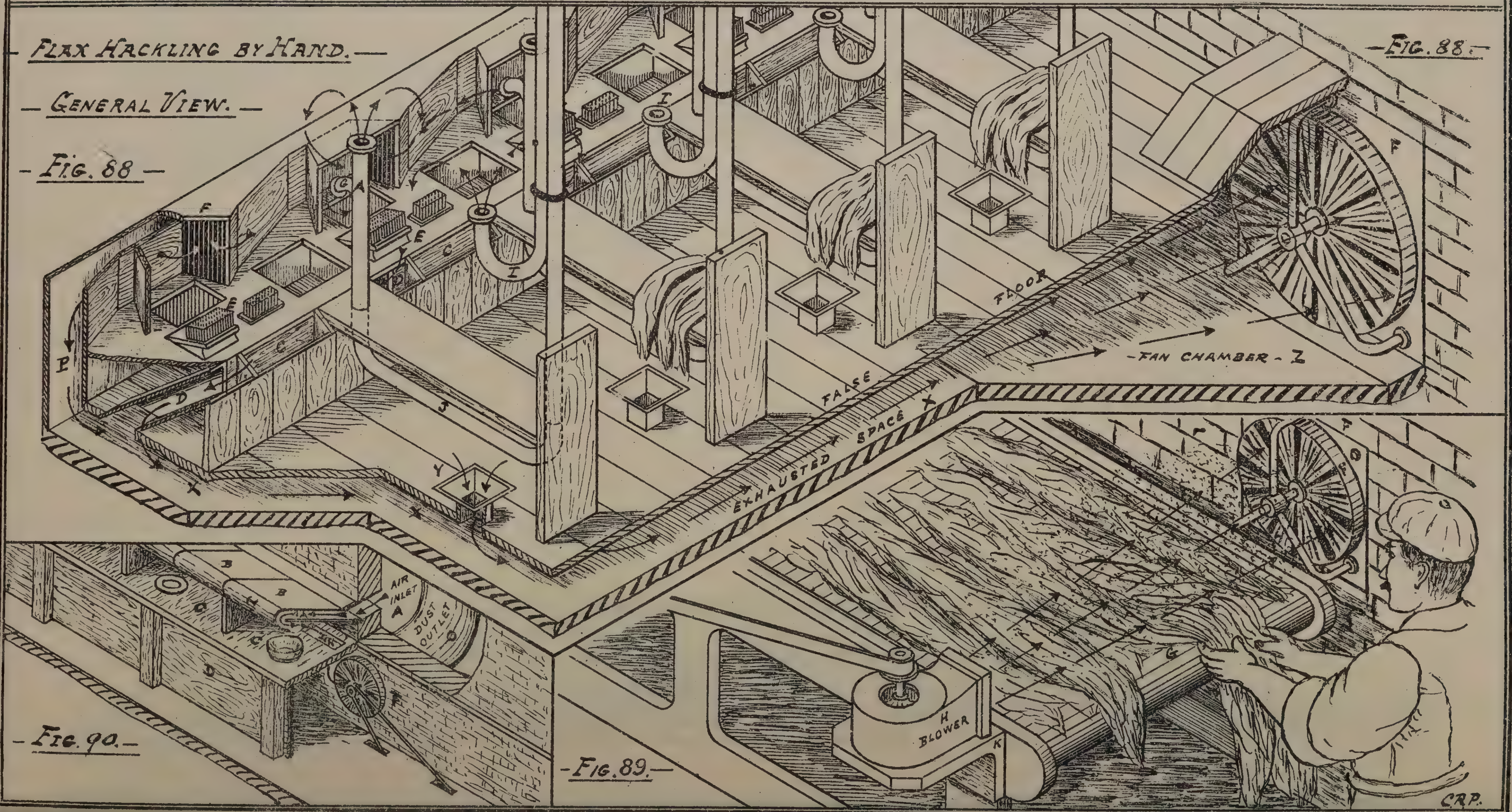

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PLATE XXXII.

Dust Removal by Dirigible Blast.

(*Drawn by the Secretary from systems in use by Messrs. J. and T. M. Greeves, Ld., Belfast* (*Fig.* 88), *Messrs. Hutchings, Shepherd & Co., Ld., Ilminster, Somerset* (*Fig.* 89), *and Messrs. Doulton's Potteries* (*Fig.* 90), *the latter from sketch submitted by H.M. Inspector, Mr. J. H. Walmsley.*)

Fig. 88 on this plate gives a general surface view of the installation shown in section 87 on the last plate ; and from it a better idea of the formation and arrangement of the various work places can be obtained, showing the air inlets and dust outlets relatively disposed. The same reference letters are used as in Fig. 87, but only one row of tables is shown.

Fig. 89 shows another case in which a direct horizontal blast was brought to bear successfully in assisting the removal of dust. The illustration discloses the feeding tray of a carding machine used for extremely dusty material. In placing this material on the travelling web, and spreading it out for even feeding, a cloud of dust is raised, and at first a propeller fan F placed in the adjoining wall and almost close to the machine was tried for the purpose of clearing this dust away ; its action, however, was so local in effect that no perceptible disappearance of the dust resulted, and recourse was had to the expedient illustrated, whereby a small centrifugal fan H was placed with its axis vertical on a bracket K at the opposite side of the frame. This fan H drove a strong blast of air right across the table where the dust was thickest and so swept a greatly increased percentage of the dust into the extraction fan F. The blower H was of a very crude type, made in a remote country mill by the factory mechanic ; but the idea is a good one, and conceivably capable of development.

Yet another and better known application of the same principle is shown in Fig. 90, only that the cross current results from the natural inrush of air to a partially exhausted room and not (in the particular instance shown) to a direct blast from a plenum fan.

The bench C C is one of a kind used in potteries for such processes as ground laying, colour blowing, &c., &c. Beneath it is a fan F which draws air downwards and backwards through a slot K, and so removes all dust arising from the process which may come within this exhaust influence.

As the exhaust current, however, is rather local in effect and does not extend very far forwards in the worker's direction it has been found possible to give a fillip to the backward flow of dust (or spray) by introducing a cross current (as indicated by the arrows) through the inlet A, bringing it forwards between two glass panes B B, which form a double-topped air guide, and then by means of a metal curve H reversing and deflecting it to meet the exhaust current at K. If the arrangement is such that the dust or spray arising from the process must pass through or into this cross current, efficient removal of all injurious particles will be doubly ensured. The inward and outward currents act in conjunction as conveyor and receiver respectively, and in so doing naturally accomplish much better results than can be produced by either system singly.

PLATE XXXIII

Textile Dust.—Open Hoods *v.* Close Nozzles.

(*Drawings by the Secretary from photos submitted by Messrs. Lawson, Fairbairn, Combe, Barbour & Co., Ltd., Belfast* (*Fig.* 91), *and from systems devised by Mr. John Gray, of The Falls Spinning Co., Conway Street, Belfast* (*Figs.* 92, 95).)

The removal of dust from machines which cannot well be thoroughly encased is often attempted by means of a large hood placed immediately over the machine with a vertical uptake, such as is shown at B B at Fig. 91. This method is seldom successful, especially when accidental drafts or currents of air are blown across between the hood and the machine, thus dispersing the dust before it can be collected into the upward stream attracted by the fan. The machine here shown is known as a " Spread-board " in the flax-spinning industry; and the dust mainly arises from layers of flax as they are in the act of receiving pressure when entering the rollers shown in the diagram Fig. 95, wherein the rising cloud of dust is indicated by the letter D. Obviously, if this dust can be snatched up by some closely applied exhaust nozzle before it has a chance to disperse over a larger area, its removal will be much more effectually accomplished. The sectional view in Fig. 94 shows this idea put into practice. At the position E under roller R, where the dust arises, a nozzle A is placed close to the roller and the dust drawn into it is passed upwards as shown by the arrows D through an uptake C towards the fan. The method bears a general resemblance to that effected by so-called vacuum cleaners, now much used for removing dust from household furniture, &c.; and in fact the latter appliance has been used very effectively in removing dust from factory rooms, machinery, and plant. Fig. 92 gives a general view of the exhaust arm A as applied in front of the rollers of a machine similar to that shown at Fig. 91, and Fig. 93 shows a reversed view of a similar arm, whereby the hoods E E can more clearly be seen and the direction of suction indicated by the arrows. This appliance is neater and more compact, less obstructive to light and far more effective, at much less expenditure of fan power than any other system tried for the purpose.

Removing Dust from Spread-Boards in Flax Spinning.

Fig. 92. by Exhaust Nozzle A Fig. 91. by Open Hood B

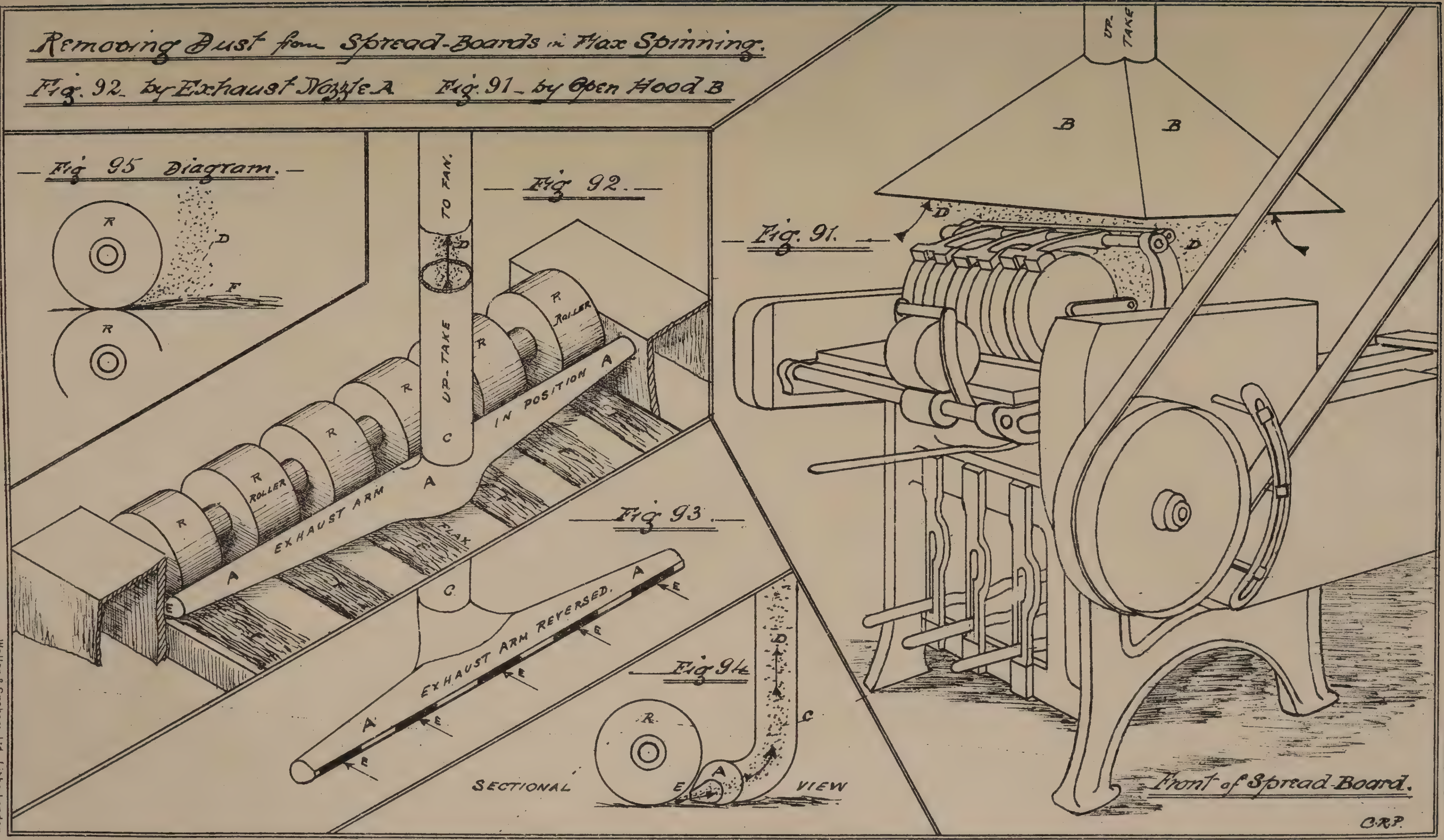

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PLATE XXXIV.

Fig. 96.

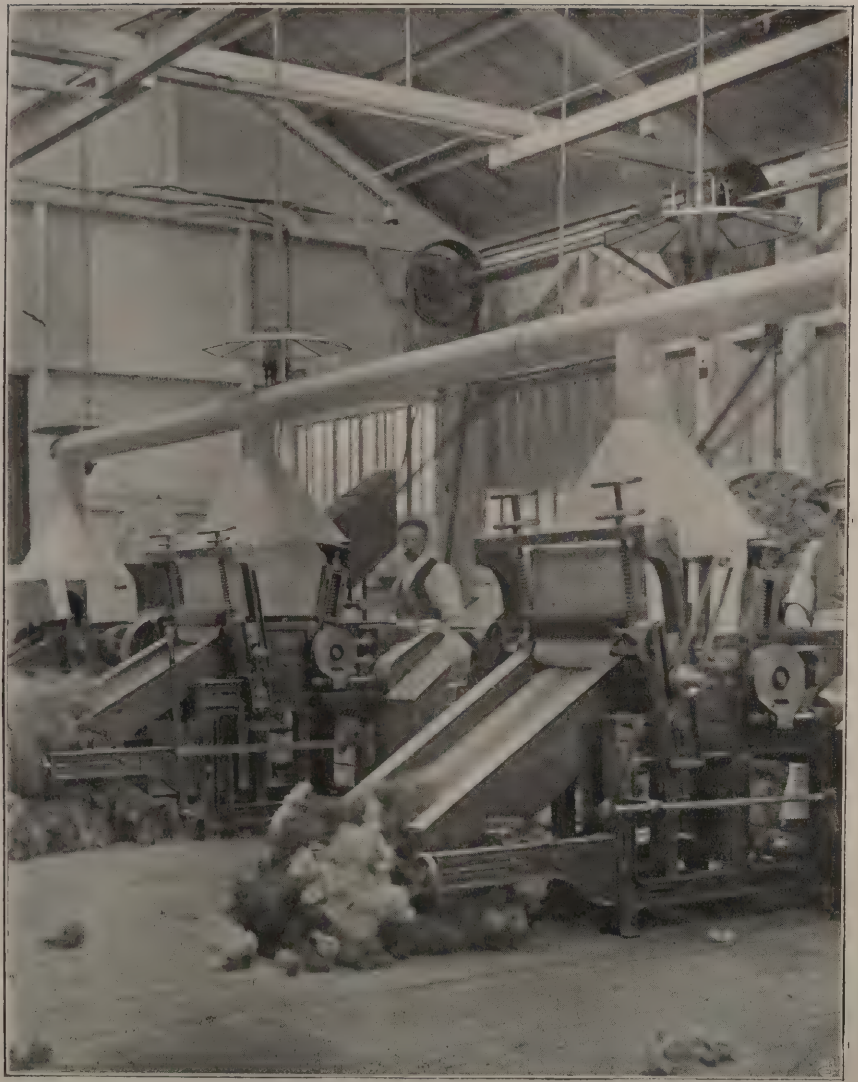


PLATE XXXIV.

Fig. 97.

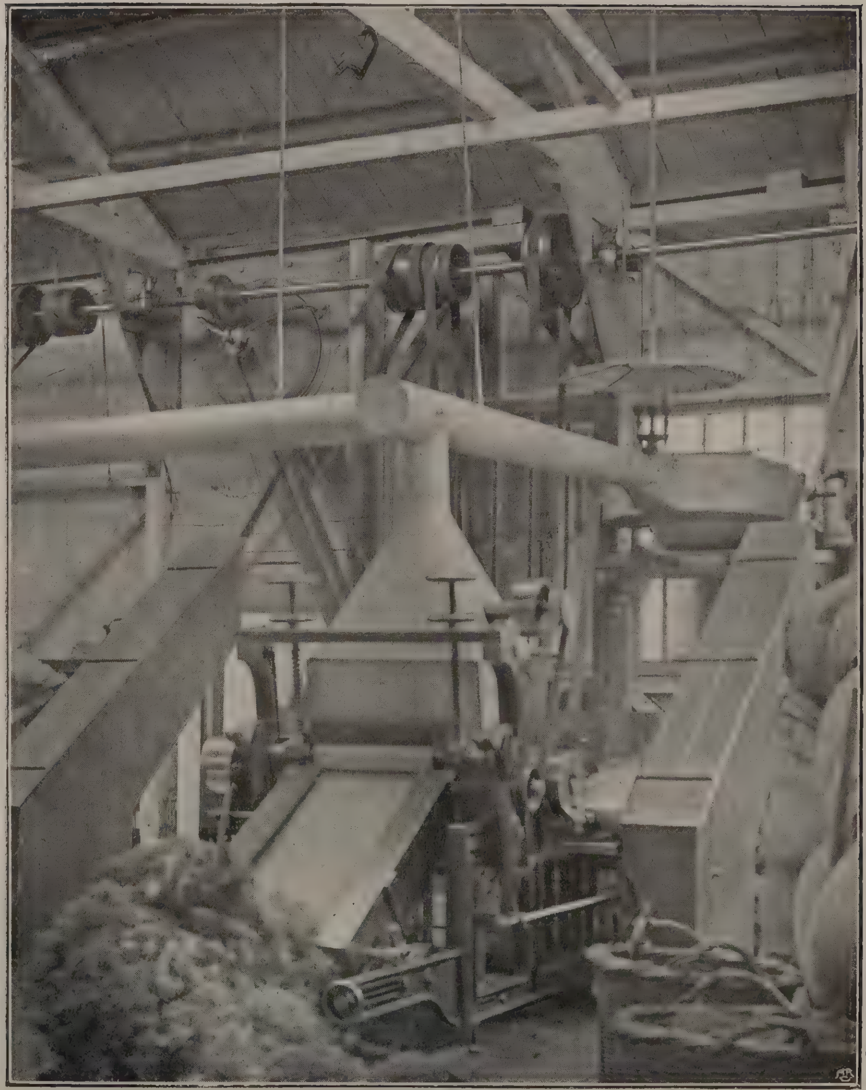


PLATE XXXIV.

Textile Dusts.—Curtained Hoods.

(*Photograph by Mr. J. Owner* (*H.M. Inspector of Factories*) *of system in use at the Great Western Railway Works, Swindon. Mr. G. J. Churchward, Chief Engineer.*)

The photographs on Plate XXXIV. illustrate a method of extracting dust from horsehair carding machines which will be found on closer study to be a sort of compromise between the two methods illustrated on Plate XXXIII. The dust arises from the pressure of rollers in much the same way as in Diagram 95, but the horsehair also passes through a series of combs before reaching the rollers and some dust is given off by that means, thus enlarging the area to be dealt with. To remove this dust, open hoods like B. B. in Fig. 91 were first used with very poor effect; then canvas curtains were dropped from the edge of the hood to the framework of the machine in such a way as to enclose nearly the whole of the dust yielding area. This experiment effected a great improvement, and the canvas curtains having been replaced by sheet metal flaps, the arrangement became very satisfactory. It will be seen that the main horizontal duct is of uniform diameter and the upcast throats between the hoods and main duct are almost equal in diameter to the main, which they enter at a decided right angle. When first tried it was found that the machine nearest the fan was considerably over exhausted, other machines receiving no benefit; annular discs were then placed in the throats to lessen the exhaust from the nearest machine and graduate the others until the farthest machine was left with almost full bore open; this done, the installation worked very successfully, the fan used being a powerful one of the blower type. The results achieved, however, would have been more economical in fan power if the main exhaust duct had been arranged as explained in previous plates and right angles been avoided. In Fig. 97 a propeller fan will be seen just under the roof; this fan is used to promote general ventilation and to remove the lighter particles of dust resulting from the movements of horsehair about the sheds. Although some seven tons of horsehair (which has formed the padding of railway cushions for a period of six or seven years previously) is handled every week in this department, where it comes to be thoroughly dusted and manipulated for further use, the entire shed is remarkable for the clearness of its air and its general cleanliness; of this the photographs themselves are a striking proof, being taken with the machines in full work as shown, a feat which would have been impracticable in a dusty atmosphere.

PLATE XXXV.

TEXTILE DUSTS (*continued*).

Photographs are shown on this plate of one of the machines before described. In Fig. 98 the metal flap on the feeding side is shown to be hanging down in the working position, and in Fig. 99 the same flap is shown lifted up as may be necessary for access to parts beneath the hood. The installation described in these two plates has been recently carried out by the Great Western Railway Company in their Carriage Works at Swindon, under the supervision of their Chief Engineer.

PLATE XXXV.

Fig. 98.

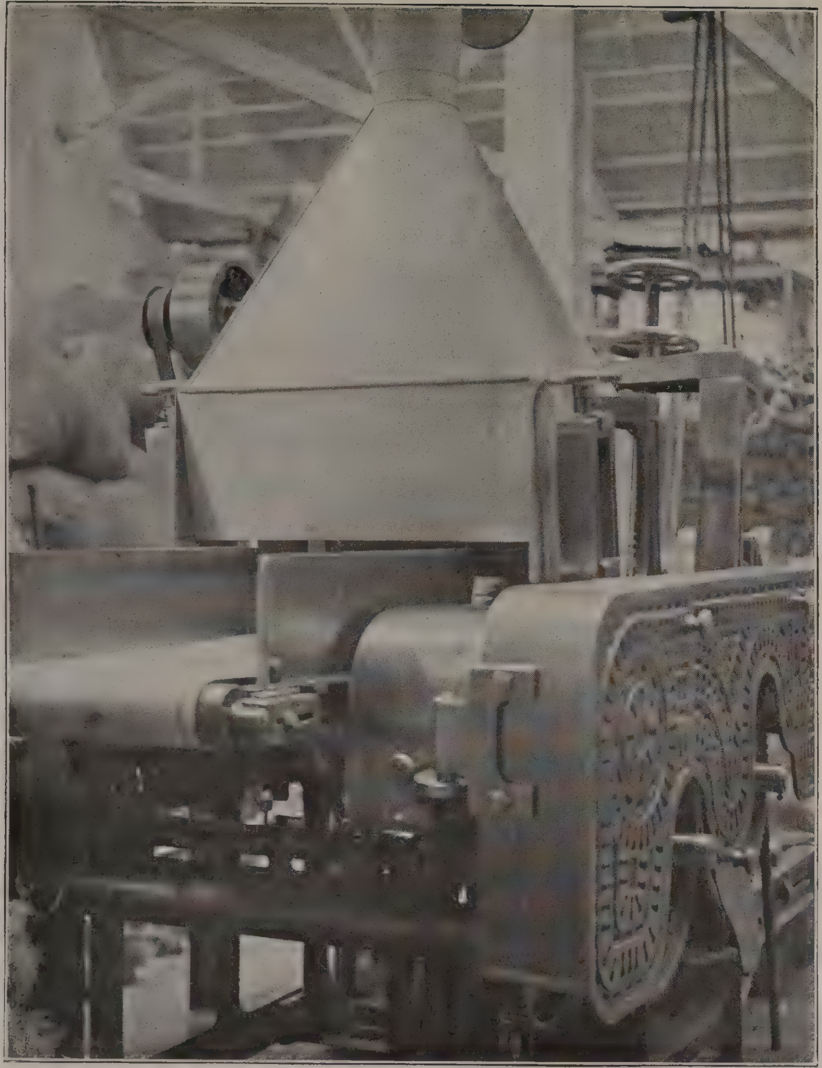
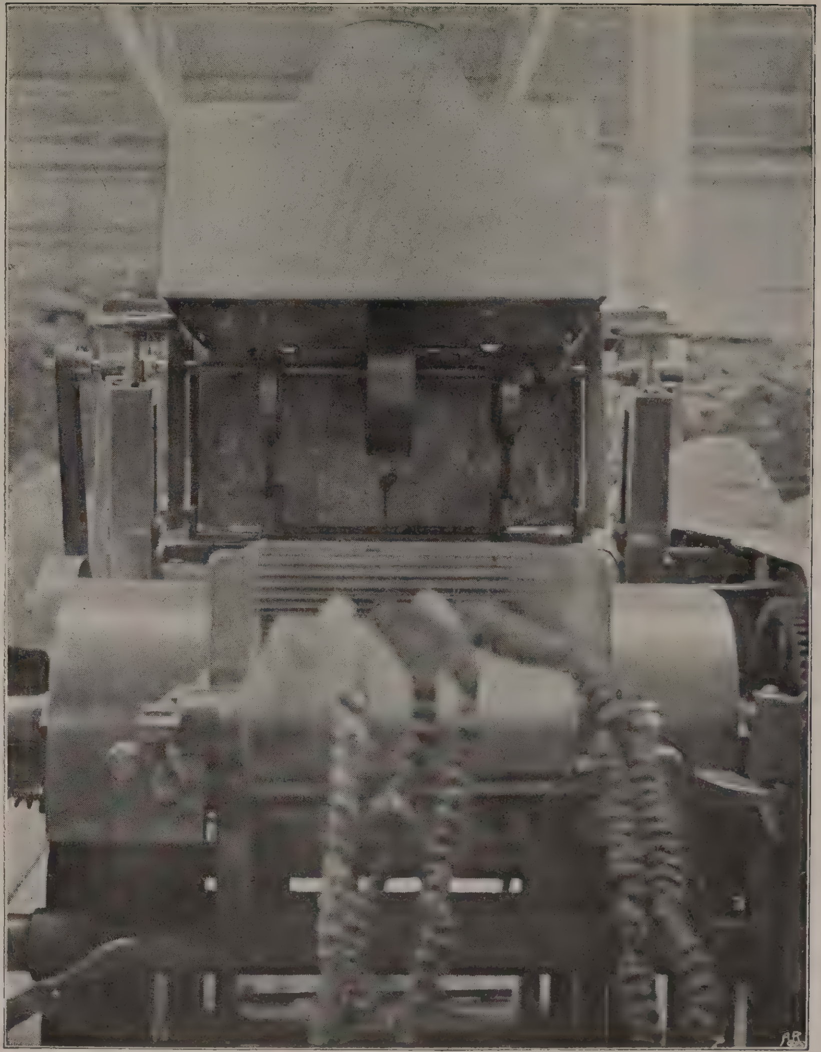


PLATE XXXV.

Fig. 99.



ARRANGEMENT OF DUST COLLECTING AND SEPARATING PLANT FOR WOOL SORTERS' TABLES.

SCALE 1/8 INCH = 1 FOOT.

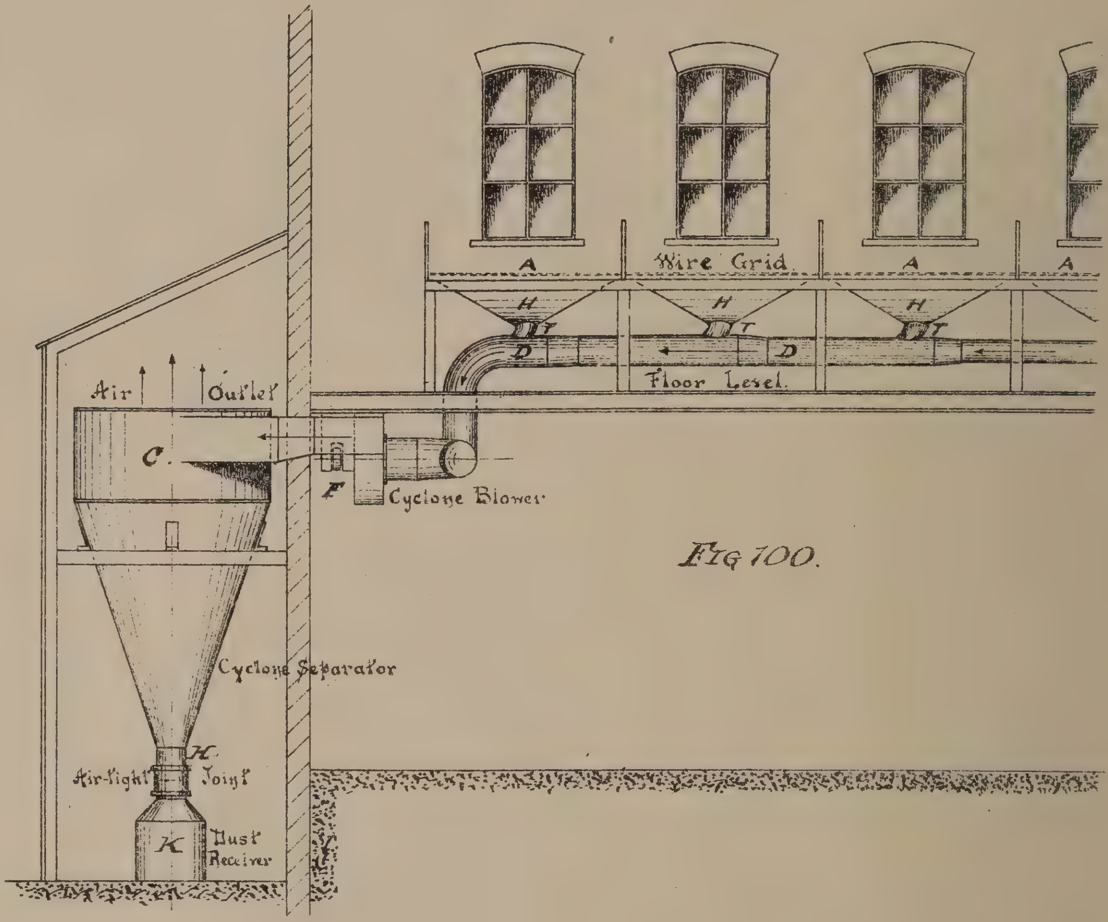


FIG 100.

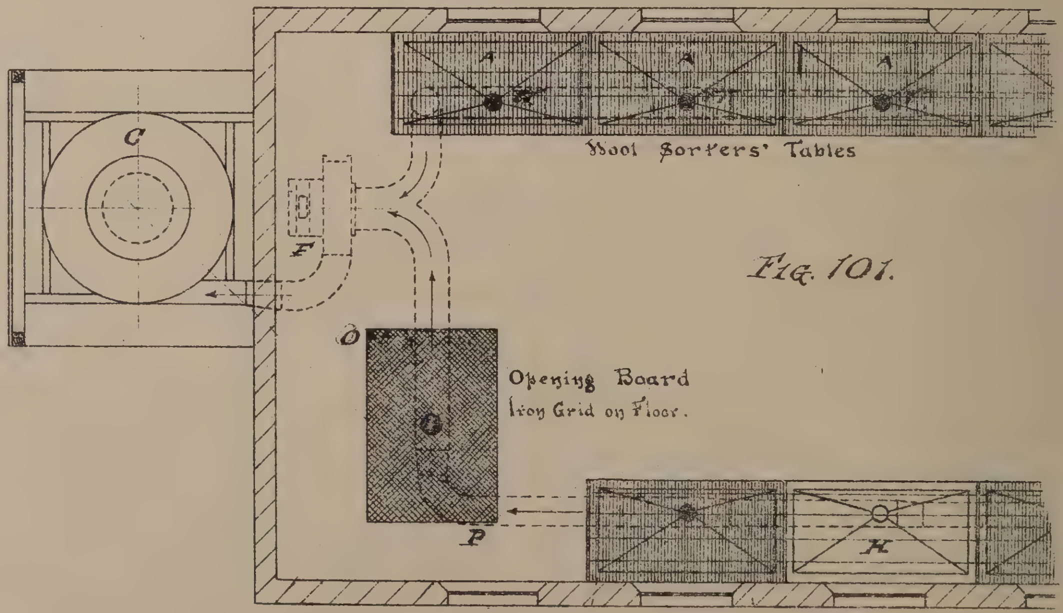


FIG. 101.

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PLATE XXXVI.

TEXTILE DUSTS.—WOOL SORTING.

(*Drawn by H.M. Inspector, Mr. L. Ward, from designs furnished by Messrs. Matthews & Yates, Engineers, Swinton.*)

The removal of dust from wool sorting tables being the subject of special rules under the Factory Act, the matter has received considerable attention on the part of wool factory occupiers and ventilating engineers, as well as of the Factory Department. The arrangement shown in Plate XXXVI. is probably one of the best for the purpose. It will be seen in Fig. 100 that beneath the wire grid on each bench a metal hopper extends at its widest part to nearly the full size of each bench. Its sides recede downwards until at the narrowest part the opening coincides in area with the throat T, connecting it at a properly turned angle with the main duct D. This duct is connected with the fan, which discharges its dust-laden air into a cyclone separator C (details of which are given on Plate XXXVII). At the foot of this cyclone there is placed a dust receiver, which has a tubular neck corresponding in size to the outlet from the separator, and a well-fitting metal sieve H is so arranged that it can be dropped over the neck of the dust receiver K in such a way as to form a dust-tight connection between it and the separator outlet. On the sieve H being raised, the connection is broken and the receiver can be removed. For the safe conveyance of this harmful dust to the furnace where it has to be burnt, the receiver K is fitted with a false bottom, and on arrival at the furnace the receiver is placed neck foremost towards the fire and the false bottom pushed upwards through the drum of the receiver, thus forcing the dust out through the neck immediately into the flames without the necessity of shaking it loosely in the open air.

Fig. 101 shows a plan of the arrangement above described. It will be seen that the throat T of each hopper is not placed exactly in the centre but is brought rather nearer to the position of the worker. The opening board O P shown in this plan is more fully illustrated in Plate VIII., Fig. 5, but the throat N of the hopper there shown, which is of the kind generally in use, is really too straight and vertical for getting the best effect (see Plate III. and experiments).

PLATE XXXVII.

TEXTILE DUSTS.—CYCLONE SEPARATOR.

(*Drawn by H.M. Inspector, Mr. L. Ward, from designs furnished by Messrs. Matthews & Yates, Engineers, Swinton, near Manchester.*)

Fig. 102 of this plate shews the formation—external and internal—of the cyclone separator before mentioned. It will be seen that the dust on entering at A with a given velocity is forced by centrifugal action towards the periphery of the cone C C, and round it beneath the spiral S S, until the bottom of the cone is reached. Meanwhile the air by which the dust was carried finds its way upwards and outwards through an air outlet O, which is considerably larger in diameter than the inlet at A, thus giving the greatest possible freedom for escape and obviating internal pressure. The result is that the dust is quietly deposited through the spout N at the foot of the cone, where it can be passed into the receiver described in Fig. 100, without any being allowed to escape.

Fig. 103 shews a reduced plan of the separator, looking at the top, whence a comparison can be made between the diameters of inlet A, the outlet for air marked O, and the outlet for dust marked N, the air outlet being considerably the largest.

"CYCLONE" SEPARATOR.

FIG. 102.

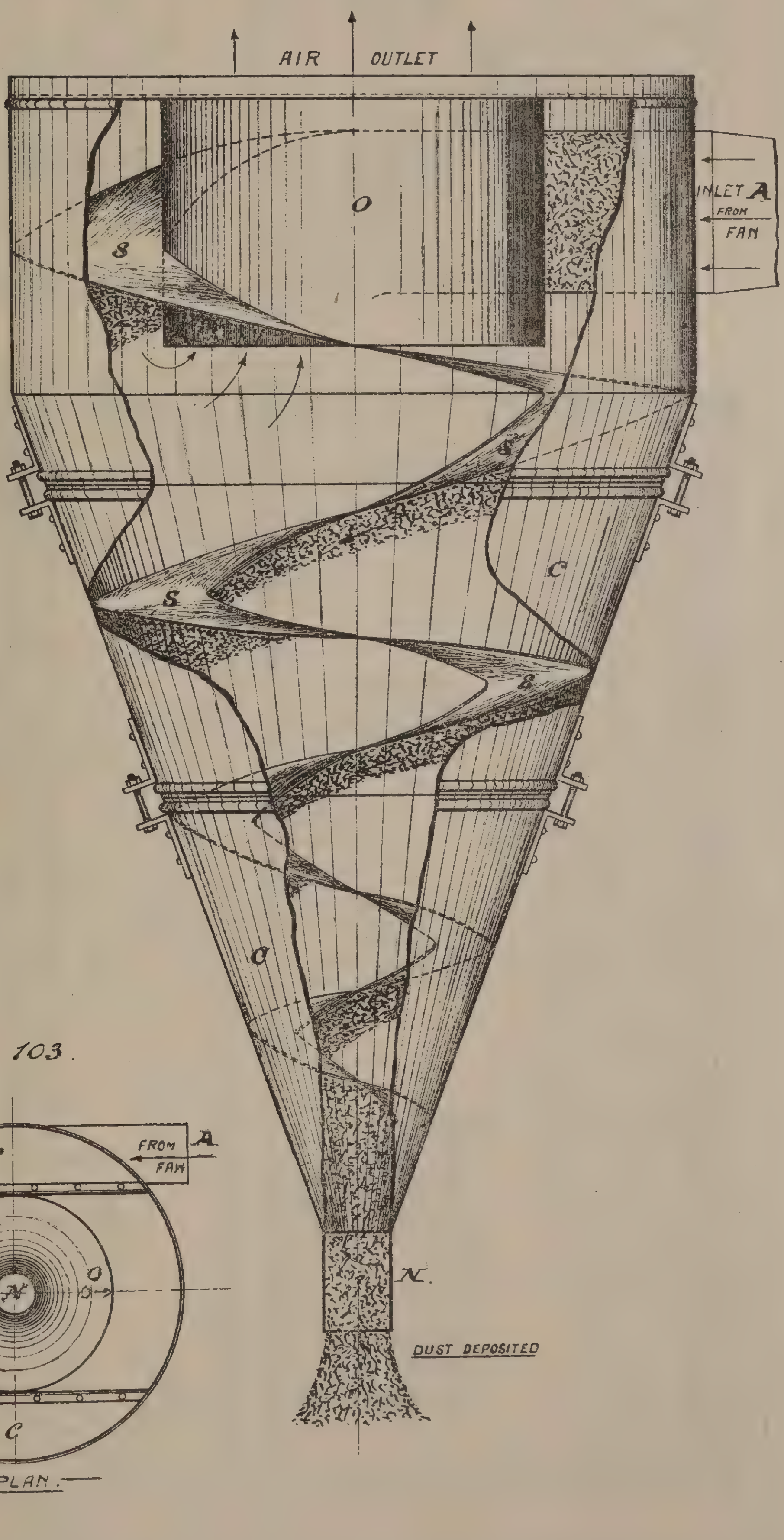
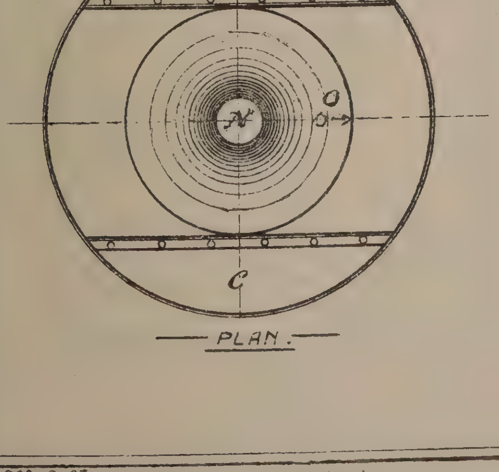


FIG. 103.



PLAN.

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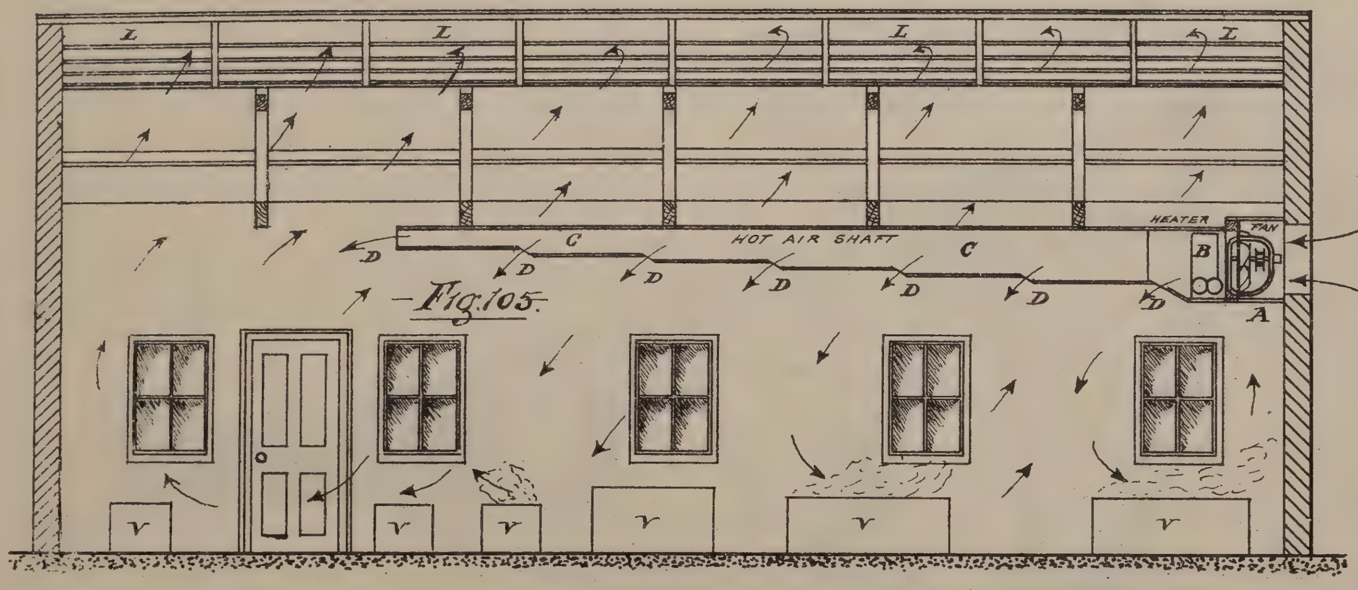
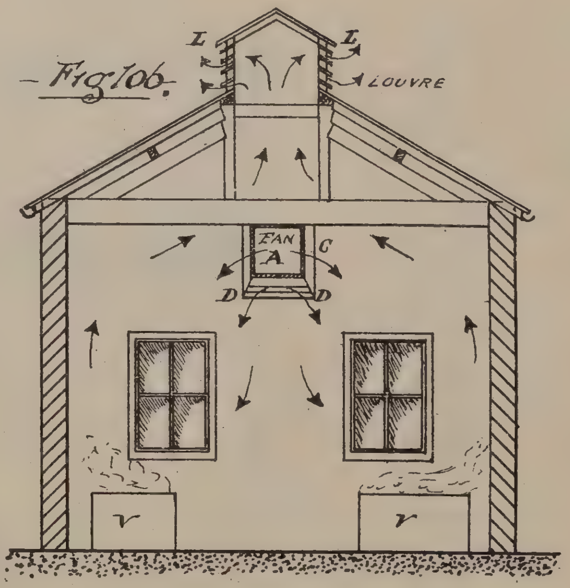
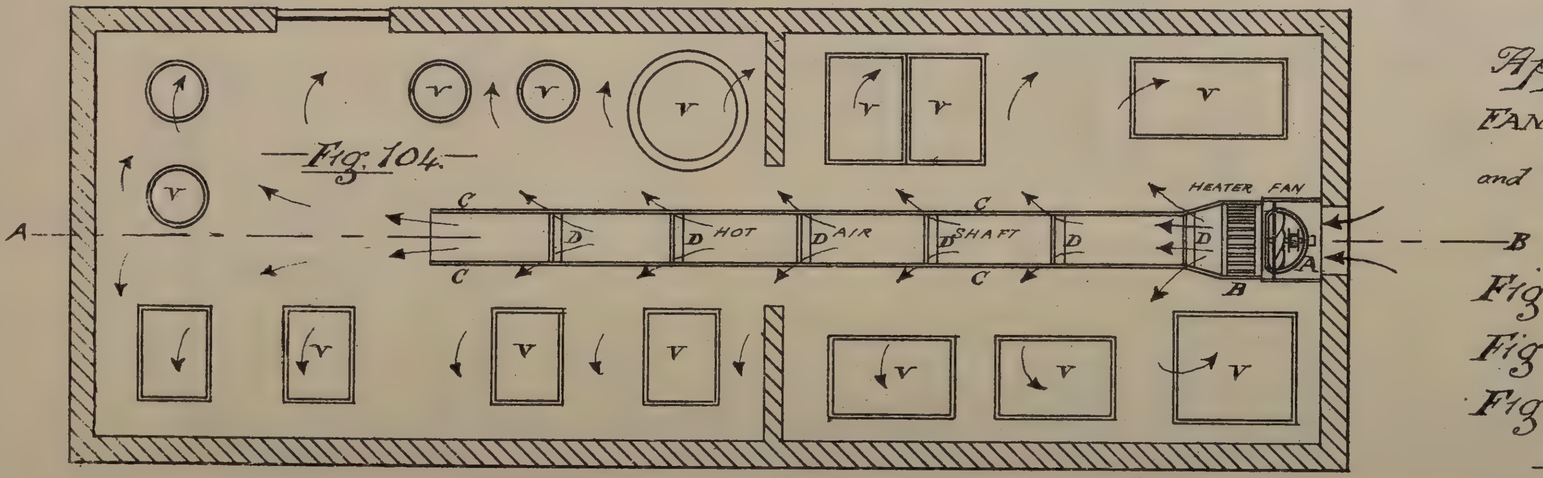


– Fig. 105.



– Fig. 106.



– Fig. 104.

Application of Propeller
FAN, with Heating Battery
and Tapered Air Shaft for
REMOVING STEAM.

Fig. 1. Plan of Dye-House.
Fig 2. Section on A.B.
Fig 3. Cross Section.

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PLATE XXXVIII.

Removal of Steam.

(*Drawn by the Secretary from plans supplied by Messrs. The Sutcliffe Ventilating Co., Ltd., Manchester.*)

The difficulties in removing steam from a building in which it is given off in large quantities such as in dye works, laundries, &c., are seldom grappled with intelligence. The most effective way of ridding such a place of visible steam clouds is to first introduce a thorough supply of air into the building sufficiently warm and dry to "kill" the steam. (A lesson may be learned from the effect produced on steam emitted from a locomotive when working in the open. On a cold damp morning such a locomotive may appear to give off dense volumes of steam, but on a dry, warm summer afternoon the same locomotive, exercising exactly the same power with precisely the same pressure in its boiler, appears to the observer scarcely to give off any steam at all. The difference entirely concerns the condition of the atmosphere into which the steam is emitted.) Plate XXXVIII. shows a dye-house in section, with steam arising from various vats and pans V V V V; and in a position midway between the eaves of the building a long tapered air-shaft C C is shown suspended from the cross beams; this air-shaft is supplied by a powerful fan A, which in cold weather drives the incoming air through a heating battery or tempering coil B B to dry and raise it to the temperature required. The tempered air is given off from the shaft at various openings in its length marked D D D D, and is forced downwards as indicated by the arrows, Fig. 105; it thus descends to meet the vapours ascending from the vats V V and mingling with them, absorbs their moisture. When the air of the interior becomes warmer and drier than the outside atmosphere, the internal air currents will ascend towards the louvre L at the ridge of the building and escape to the outside.

PLATE XXXIX.

REMOVAL OF FUMES.

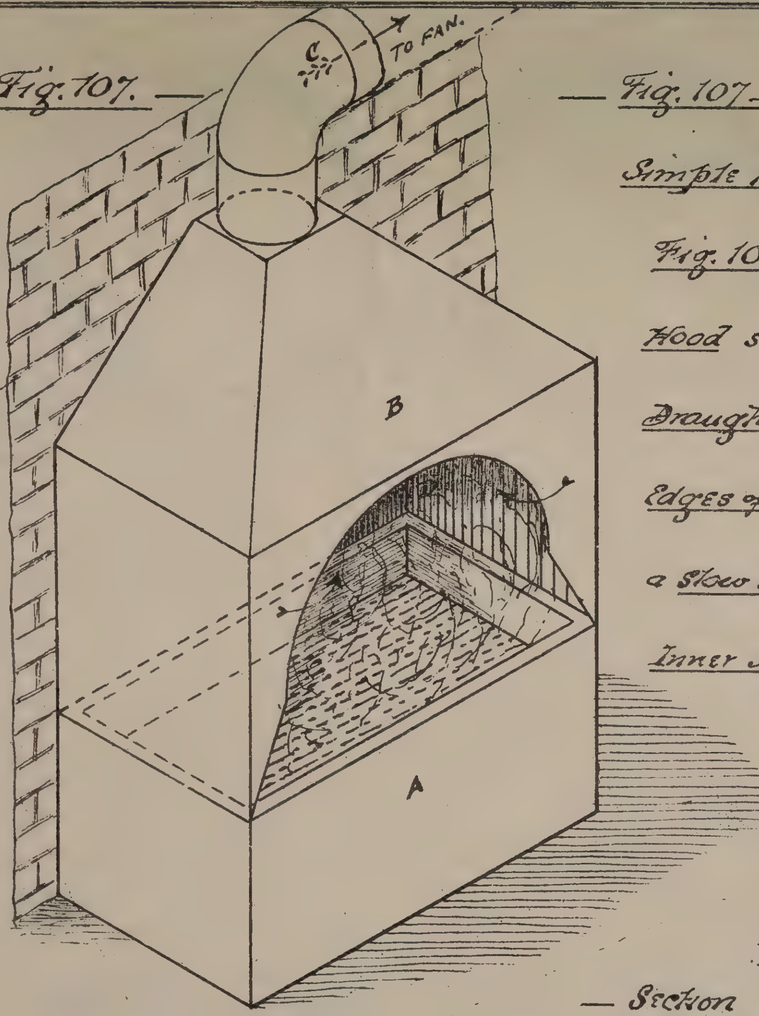
(*Drawn by the Secretary from sketches made in the Great Western Railway Co.'s Works, Swindon, and elsewhere.*)

Fig. 107 shows a simple hood B for the removal of fumes arising from an acid tank A. The apex is connected to a duct C, exhausted by fan. It will be seen that the opening at D is not greater than necessary to permit convenient access to the tank, for the larger this opening the greater will be the fan power required to prevent the fumes from coming outward.

Fig. 108 shews a hood of rather more complicated and ingenious design. It really consists of two hoods, one within the other (*see* the section in Fig. 109). The inner shell N has a large opening at the bottom, with a small outlet towards the fan at its apex, and its effect would be to slowly remove fumes gently arising from the main body of liquid in the tank. The main feature of the device, however, is the narrow space between the inner shell and the outer one, by means of which the inner shell N is surrounded by a quick draft indicated by the arrows MN, Fig. 109, the effect of which draft is to snatch, so to speak, any fugitive cloud of vapour that may be puffed outwards at the edge of the vat. The latter contrivance has been in use for some years in the Brass Lacquering Shop at the Great Western Railway Works, Swindon. (Mr. G. J. Churchward, Chief Engineer and Superintendent.)

—Removal of Fumes from Acid Tanks, Vats Etc: by means of Hoods connected to Exhaust Fan.—

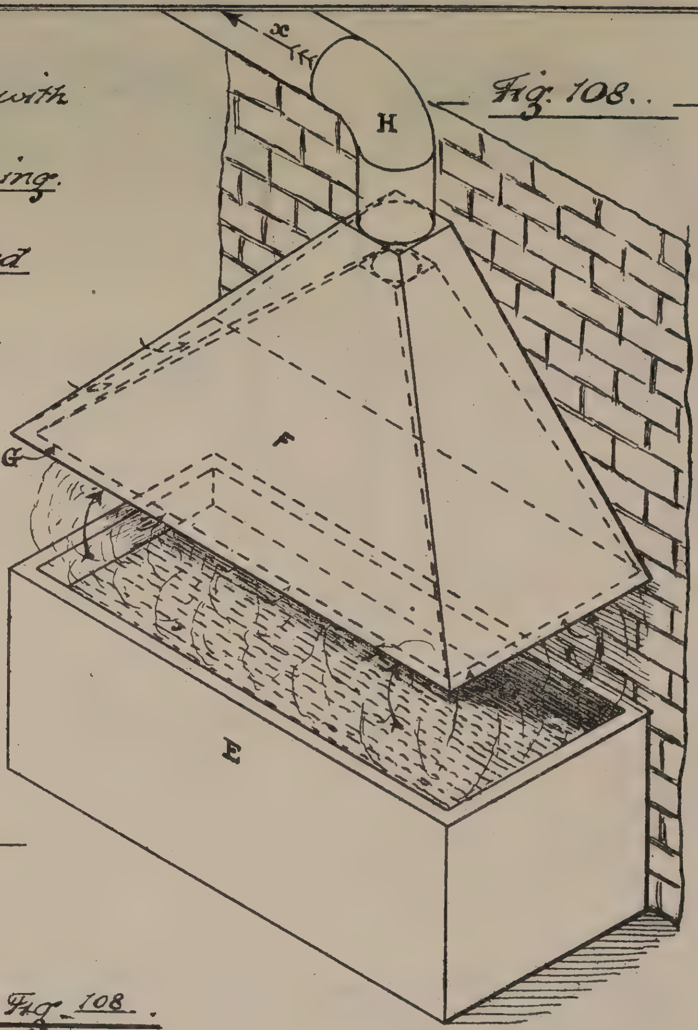
—Fig. 107.—



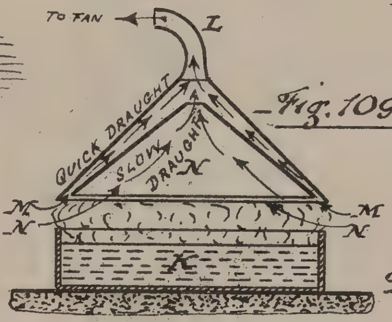
—Fig. 107_ shows a Tank covered with Simple Hood with Restricted Opening.

Fig. 108_ shows a Double-Shelled Hood so arranged that a Quick-Draught is ensured between the Edges of Inner & Outer Hoods, and a Slow Draught only in the Inner Area (see N in Section below)

—Fig. 108.—



—Fig. 109.—



— Section of Fig. 108.

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PLATE XL.

802. 2. 07.

SYSTEM OF REMOVING BENZOLE FUMES IN THE PROCESS OF FRENCH CLEANING.

NOT TO SCALE.

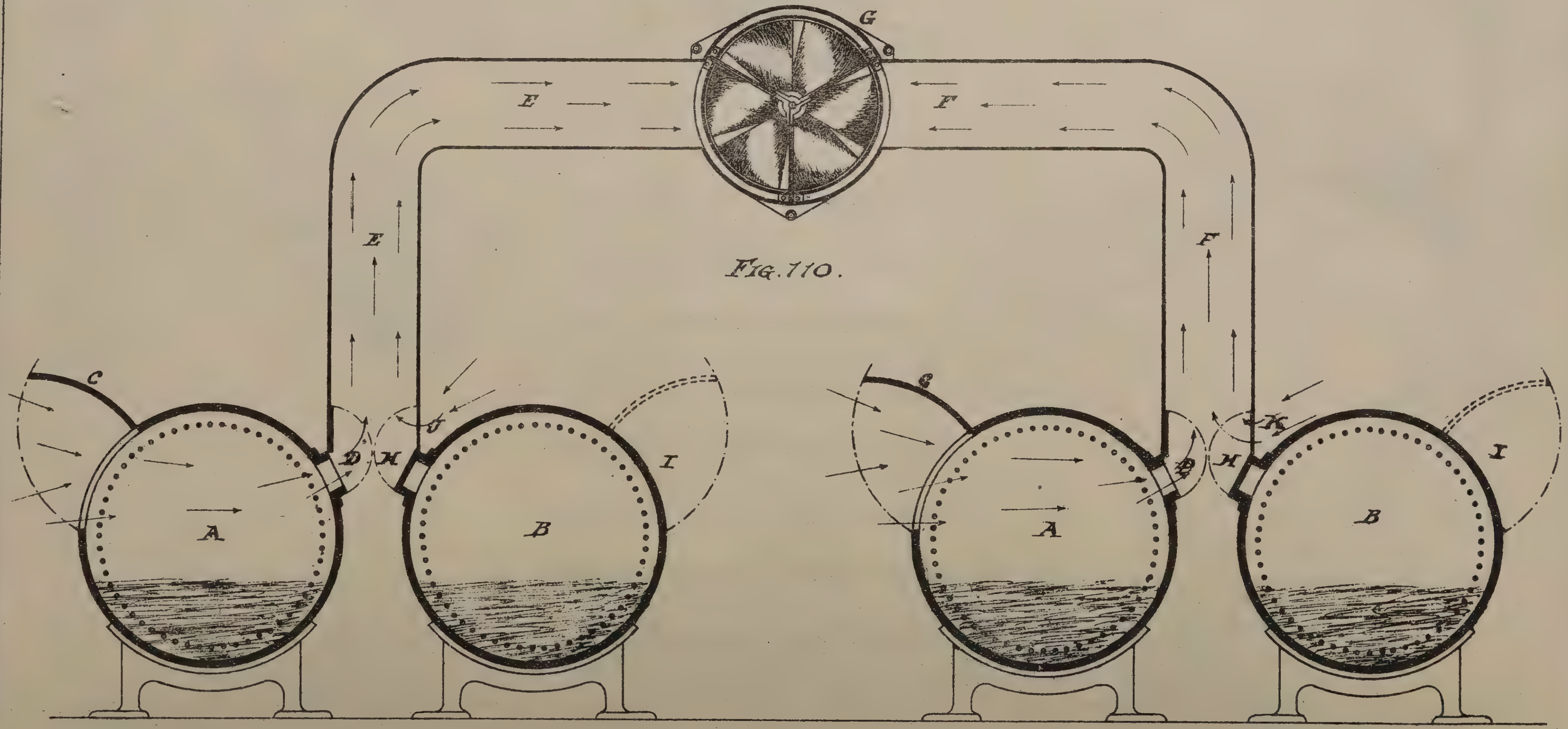

FIG. 110.

DIAGRAMMATIC SECTION.

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PLATE XI.

Removal of Benzole Fumes.

(*Diagram drawn by H.M. Inspector, Mr. L. Ward, from designs furnished by Mr. Statham, of The J. Keith and Blackman Co., Ltd., Engineers, London.*)

Fig. 11 shews a diagrammatic section of an ingenious arrangement for ventilating cylinders in which benzole is used for the process of French cleaning. It will be seen that these cylinders are arranged in two pairs, each pair connected by a duct E and F to an exhaust propeller fan G. The covers and valves of these cylinders are so arranged that when those of cylinder A are open those of cylinder B are closed. In the drawing the covers C and valve D of cylinder A are shewn open, and in that position they permit of a current of air being drawn right through the empty cylinder A into the exhaust trunk E, thus carrying away the benzole fumes and preventing their escape through the cover hole C. The door I and valve H of the filled cylinder B, on the other hand, are closed ; but the closing of the valve H makes an opening at J and K which allows air to pass over the cylinder into the exhaust ducts C and F, carrying away any fumes still remaining in the air of the room.

PLATE XLI.

REMOVAL OF HOT FUMES FROM SOLDERERS' STOVES.

(*System in use by Messrs. The British American Tobacco Co., Ltd., Bristol; "Sirocco" Fan by Messrs. Davidson & Co., Belfast; Metal piping, &c. by Mr. T. S. Hall, Bristol. Drawing by the Secretary.*)

The emission of hot fumes from a number of these small stoves in a large workshop renders the air very hot and unsuitable for working in. In a large workroom of this kind, where the fumes were allowed to escape into the common air of the room, an ineffectual attempt was made to remove them by means of large propeller fans exhausting through outlets in each wall. A much better plan has since been adopted. Each stove B (Figs. 111, 112, and 113) is covered with a small cap or hood C which on the front side has an extension H over the openings into which the soldering iron is placed, and from which the hot flame usually issues as shewn at X in Figs. 111 and 113. At the back of cap C there is another extension to which is connected a branch duct or downcast E leading to a tapered metal main duct F exhausted by a powerful centrifugal fan. Each stove B has also a small chimney D from which flame issues, but the effect of the fan suction is to draw a current of air upwards through the hood extension C X (Fig. 113) across and backwards over the stove B and chimney D and downwards through the pipe E to main duct F, the consequence being that all the impurities and products of combustion are carried right away from the worker and out of the factory without being allowed to disseminate in the common air of the room. The hoods can be made of sheet metal or cast iron, and may be lined with asbestos to prevent both their destruction by the fumes, and unnecessary radiation of heat into the room.

PLATE XLI.

Exhausting Hot Fumes from Solderers' — Stoves by means of Centrifugal Fan with Sheet-Metal Ducts and Cast-iron Caps or Hoods.

These Fittings may be lined with Asbestos if required.

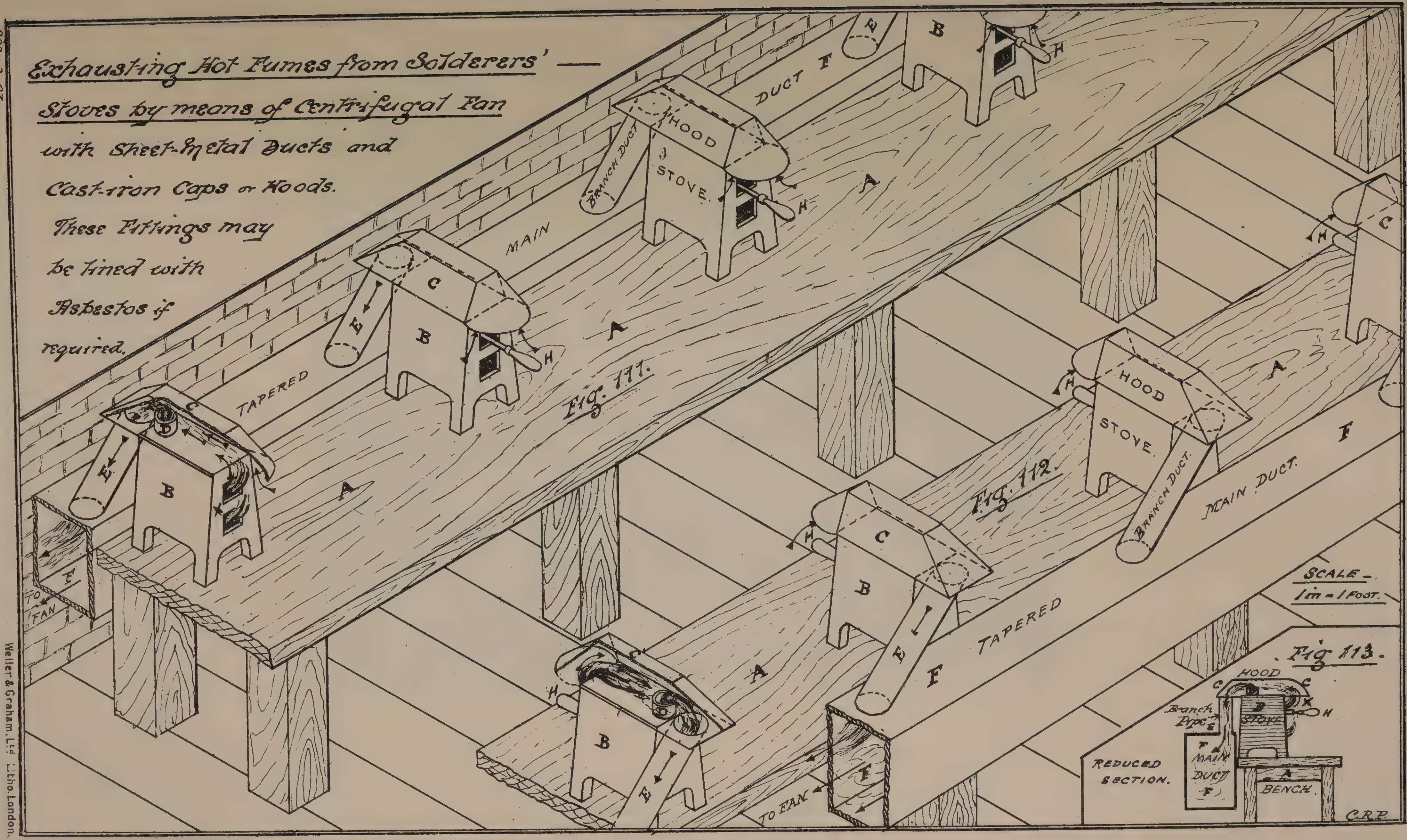

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PLATE XLII.

FIG. 114.

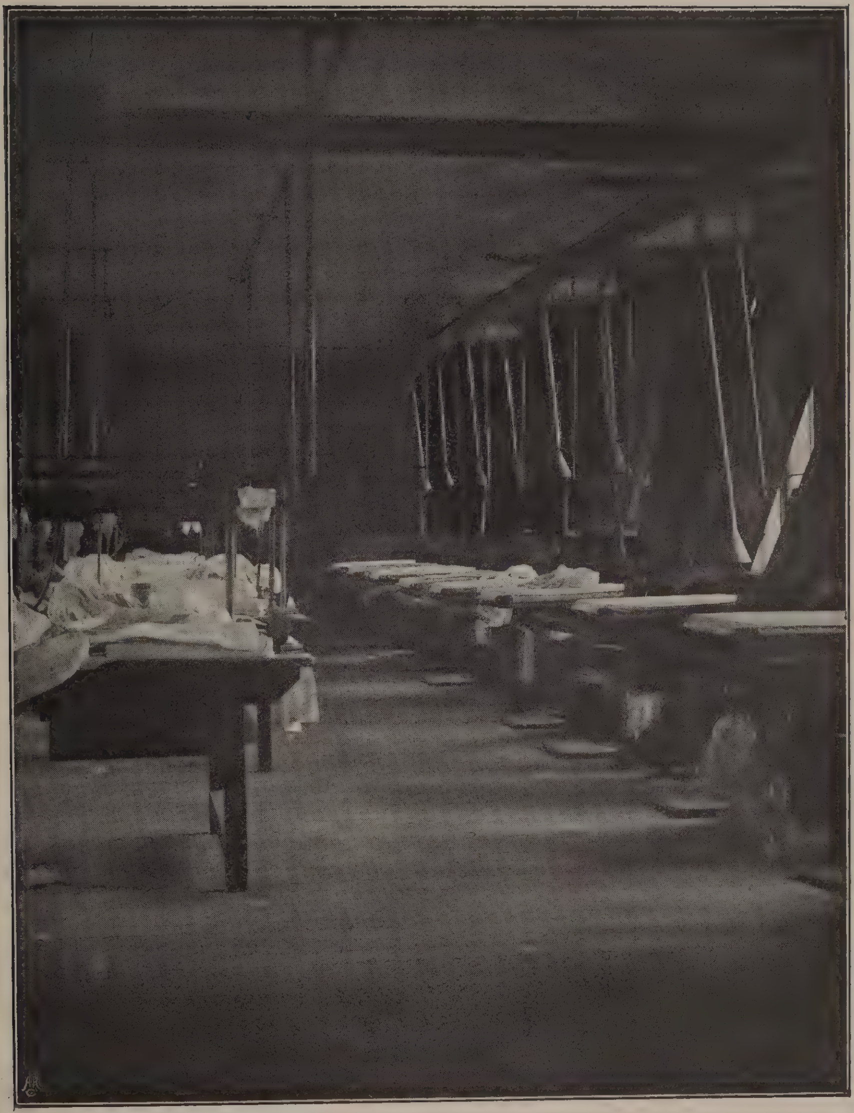


PLATE XLII.

FIG. 115.

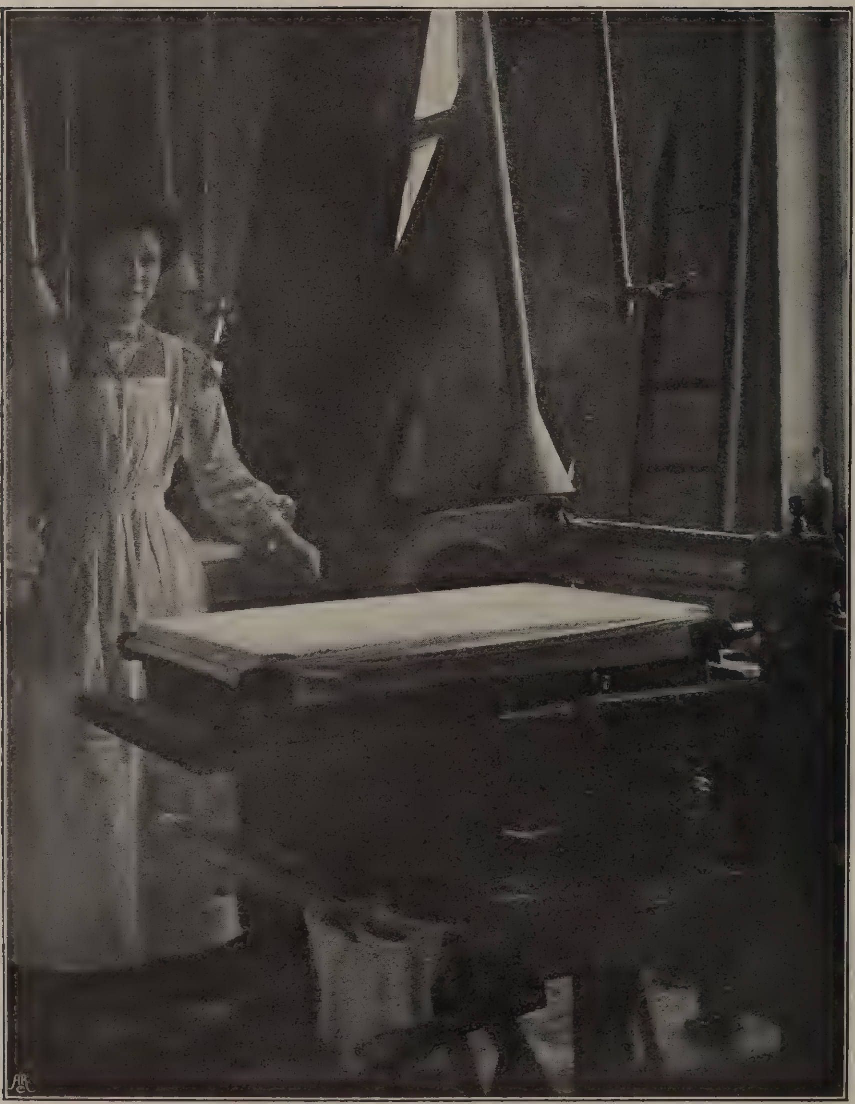


PLATE XLII.

Removal of Hot Fumes from Collar Ironing Machines.

(*Photographs by H.M. Inspector, Mr. J. Owner, of system installed for Mr. A. Seward, Collar Manufacturer, Gloucester, by Messrs. W. Gardner & Sons, Ltd., Gloucester, Engineers.*)

In the large ironing rooms of laundries and collar factories, &c., the hot fumes arising from a number of gas-heated rollers render the atmosphere overheated and unpleasant; and attempts to improve matters by means of open propeller fans are seldom effectual. What is far more satisfactory from all points of view is an installation such as that shewn in Figs. 114 and 115, Plate XLII. Fig. 115 shews an ironing machine having over the place where the fumes are generally emitted from the gas-heated roller, an inverted funnel connected with a vertical pipe, which in its turn is joined to a horizontal main duct near the ceiling, the latter exhausted by a centrifugal fan. By this means the hot impure air is drawn off immediately above its source without being allowed to mix with the air breathed by the workers. In Fig. 114 a general view is given of the overhead main duct and its suspended branches. It will be seen that the six machines in the background were originally provided with chimneys of their own, each about 3 or 4 feet high, and the exhaust funnels are carried down to meet those chimneys instead of being brought right down to the roller exhaust as shewn on the machine in the foreground.

A feature of interest to laundrymen and to manufacturers is the withdrawal of smuts, &c. that would otherwise be deposited upon the linen, whilst the improvement in the general atmospheric condition is of unquestionable benefit in all other respects.

PLATE XLIII.

REMOVAL OF FUMES IN MATCH WORKS.

(*System installed at Messrs. Moreland's Matchworks, Gloucester. Mr. R. Stotesbury, Bristol, Engineer. Drawings by the Secretary.*)

Many attempts have been made to remove satisfactorily the fumes given off from matches in the process of box filling, but one of the most ingenious is shewn on Plate XLIII. The berths at which the girls work are shewn at AAAA in Fig. 116, and it will be observed that the partition PP between each berth and the next is covered by a hood H of a roof-like pattern with a branch pipe D connecting its hinder part with the main exhaust duct CC which leads to a powerful centrifugal fan. In the process of boxing, the girl upends on one side of her berth a frame of newly dried matches M M, and on the other side a large square tray in which she places the boxes BB as she fills them. Consequently the hood covering each partition will have beneath it both a tray of boxes and a frame of matches. In the foreground of the illustration sections of these hoods are given so as to reveal the inclined plates XY beneath them, which tend to equalize the air currents being drawn towards the fan. If it were not for these plates XY the suction would be very rapid at the rear of the hood near the hole E, but imperceptible nearer the worker, thus producing the opposite effect to that desired.

PLATE XLIIIA.

REMOVAL OF FUMES IN MATCH WORKS. EXPERIMENTS IN SURFACE VENTILATION.

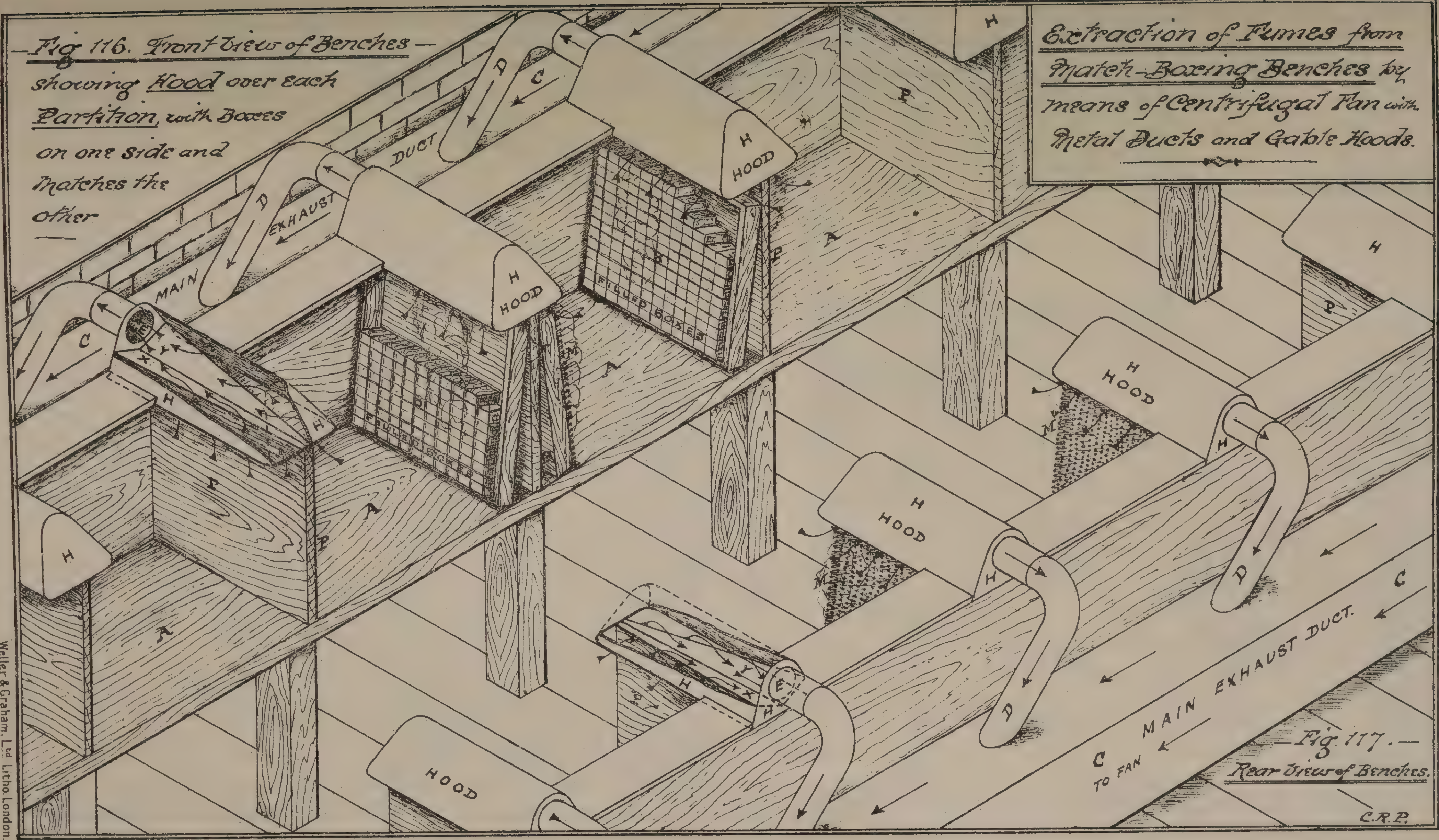
(*Designs by the Secretary.*)

Although the system designed in Plate XLIII. was much in advance of any previously tried, it was found when careful tests were made that the fumes arising from the level portion of the bench were not carried off, and the women in leaning over their work were still receiving the fumes in their faces, except such as were drawn off at the sides, as before described. The fumes were found chiefly to arise from matches strewn about the bench immediately below the workers' faces, and it was thought necessary to devise some better method of completely removing them; accordingly some experiments were undertaken by the Secretary which proved successful and particularly interesting as showing how a directed blast of air can be made to assist an exhaust current by forcing the fumes to a convenient point for extraction.

After various improvements had been proposed and tried without success, the arrangements shewn in Figures 116A and 117A were found to be completely successful under a variety of tests.

As suction alone would not remove the fumes owing to the extensive area over which they were given off, and as any exhaust appliances that could be fitted in the only available positions would either be too small and limited in influence, or if large enough would absorb too much air for their effective action, a blast was introduced to blow off the fumes instead of withdrawing them by suction. At first the blast current was tried by itself, and it was found easily practicable to carry the fumes in any required direction so long as no part of the current was obstructed, but if any obstacle was encountered, the effect was to set up mischievous eddies or deviations of the current. In the first arrangement tried, the back of each bench was boarded over and presented a solid surface to the impinging column of air, thus causing

Extraction of Fumes from Match-Boxing Benches by means of Centrifugal Fan with Metal Ducts and Gable Hoods.



—Fig 116. Front View of Benches— showing Hood over each Partition, with Boxes on one side and Matches the other

—Fig 117.— Rear View of Benches.

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PLATE XLIIIA.

EXPERIMENTS WITH BLAST AND EXHAUST AIR CURRENTS FOR REMOVAL OF PHOSPHORUS FUMES.

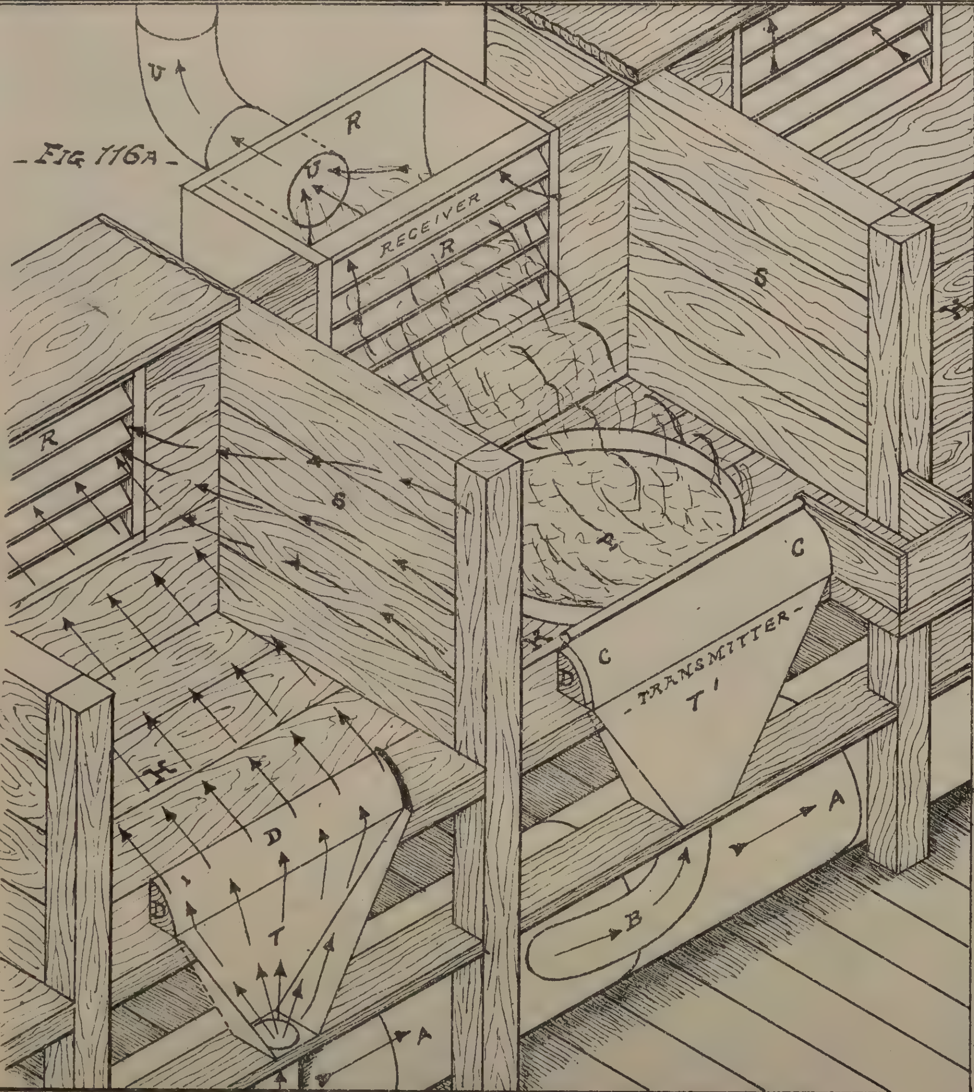

FIG 116A

GENERAL VIEW OF BENCHES SHOWING ACTION OF CURRENT ON FUMES.

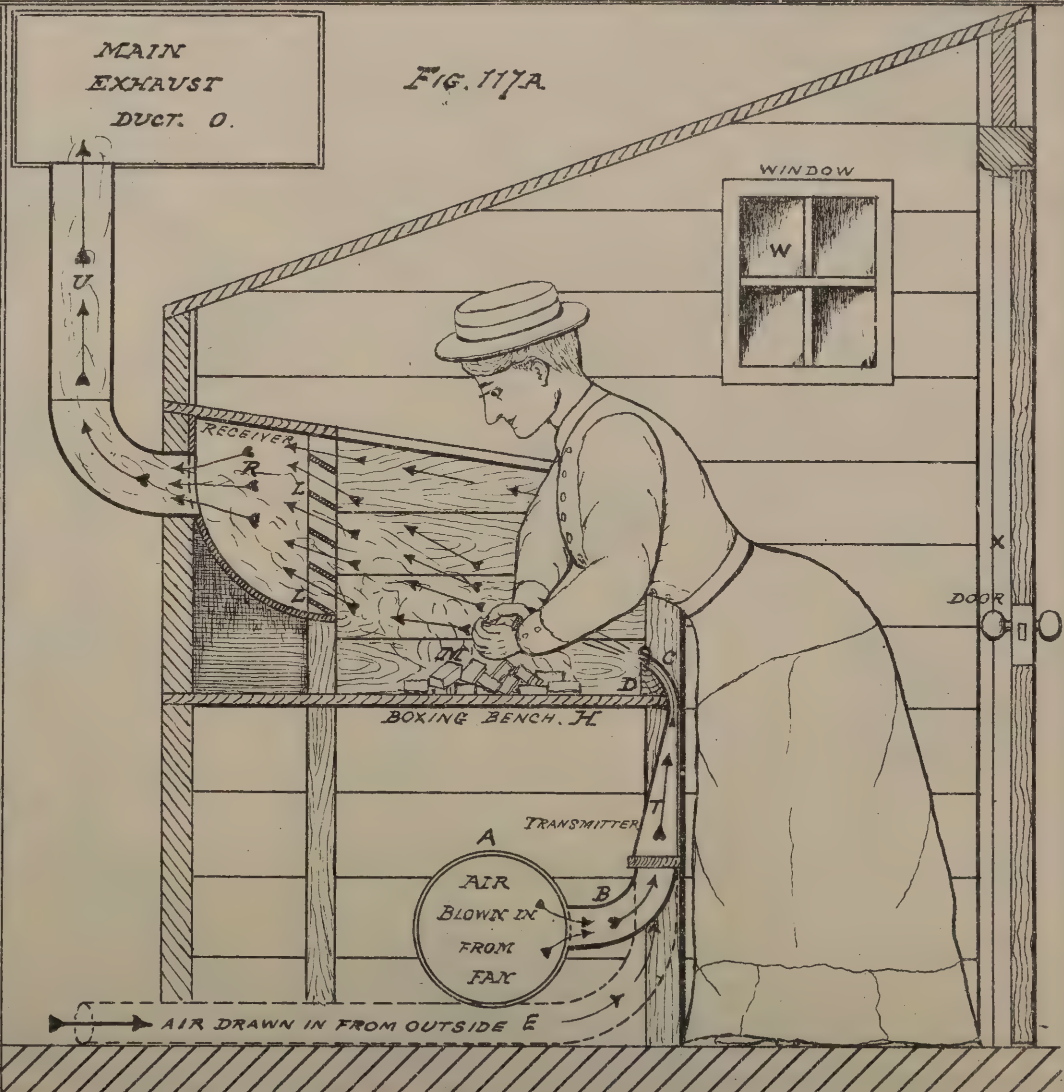

FIG. 117A

SECTION OF HUT SHOWING ALTERNATIVE EXPERIMENT WITH EXHAUST ONLY.

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the latter to rebound direct into the worker's face, carrying all the fumes with it. Consequently, it was found necessary to place in the back of each berth a louvred grating rather larger in section than the column of air, and this was so arranged that the air could easily flow through it into a hollow receiver at the back, which acted as a gentle cushion and so prevented the deflection otherwise caused. This receiver R was then connected by an uptake V to the main channel leading to an exhaust fan, so that a system of cross ventilation was established between a blast nozzle or transmitter T at the *front* of the bench and the hollow exhaust receiver at the *back*; the effect being to set up a broad stratum or stream of air constantly travelling away from the worker and thus carrying off impurities and bringing her a constant supply of fresh air to breathe; as the force of the blast from the transmitter T did not require to be very strong, and could be warmed at pleasure, she suffered no inconvenience whatever from the movement of air, as all such motion was in front of and away from her.

Reference to the Figure 116A and Section 117A will show how the cross current was produced and how some of the tests were applied. It will be seen that the air supply for the blast transmitter T is derived from a main trunk A connected with a so-called "plenum" fan, the air from which is warmed by passing over a steam radiator. The connection between the main duct A and transmitter T is effected by a carefully curved junction piece B, which opens into the root of a tapered distributor which is shewn in Figure 116A with its covers T1 and CC removed. The air was forced through a narrow passage formed between a rounded block D and concave plate or cover CC, and was not allowed to emerge on a level with the bench for two reasons; (a) matches and waste were prevented from entering the transmitter by keeping the block D about three inches high, and (b) the current of air was made to cross the bench a little above the usual pile of match boxes, &c., so as to pass between the matches and the worker's person.

When it was found that a blast from a plenum fan had the desired effect of urging the fumes across the bench towards the receiver a further experiment was tried in a hut which could be entirely closed except for one opening connected by a longer pipe E to the same transmitter, the original plenum air-supply being dispensed with; this inlet pipe E is shown in dotted lines (Figure 117A). When the door of this hut was closed, and the exhaust fan connected to the receiver R was set in motion, the effect was to set up a partial vacuum in the hut which could only be satisfied by air drawn in from the outside through the pipe E and transmitter T; the result was that the same cross current as before was produced with equal effect by the operation of one fan.

In testing this arrangement specially prepared smoke-paper was used to trace the movement of the various air currents, and the arrows shown in Figure 116A clearly show the results both over the bottom of the bench and at the sides S when tested with the worker standing in the leaning position indicated in Figure 117A. A shallow pan of boiling water P was also placed on the level of the bench, the steam being carried off as shown in the central berth (Figure 116A), Another test was to insert smoking paper in the inlet pipes B or E, the path of the smoke being thus proved to be much the same as that taken by the steam.

In practice the transmitter need only be about twenty inches wide, the space on either side of it being taken up by a box G for the deposit of waste, &c.

During the experiments air valves were placed both in the inlet pipe B and in the outlet pipe U so that the supply and force of the current could be regulated to requirements.

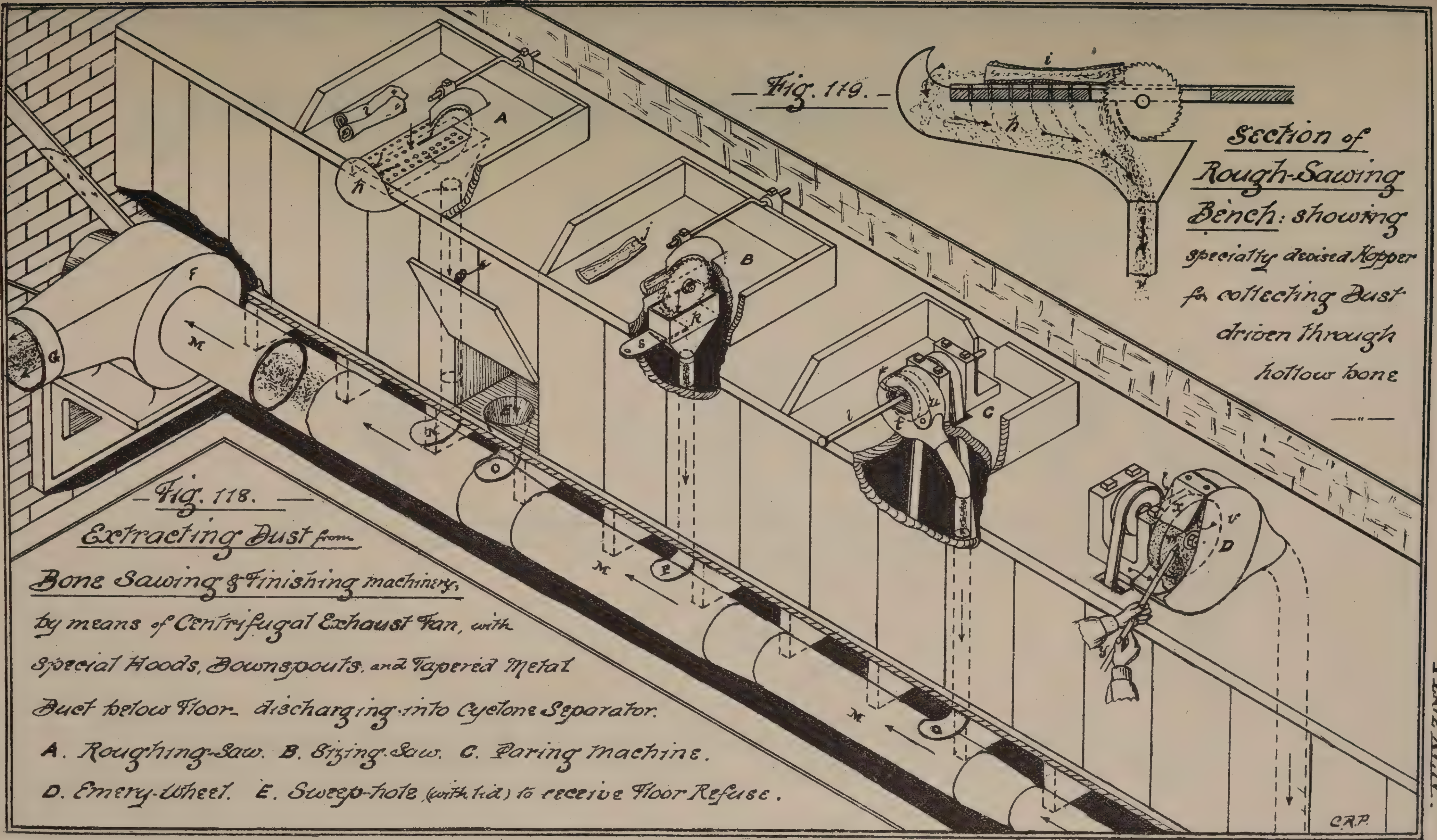
PLATE XLIV.

Extraction of Bone Dust.

(*System installed at Messrs. Critchley Bros.' Bone Works, near Stroud, by Messrs. W. Gardner & Sons, Ltd., Gloucester. Drawings by the Secretary.*)

The arrangement shewn on Plate XLIV. is an interesting example of dust extraction by specialised hoods and hoppers. The machine A is a saw for splitting the bone into halves A, Fig. 118. In the course of this process a part of the sawdust is driven right through the hollow bone, and would impinge against the sawyer's clothes and thence rebound to his face if it were not for a specially contrived hopper *h*, shown in the section at Fig. 119. This hopper extends slightly beyond and above the edge of the bench, and receives all the saw-dust from the bone *i* in the way indicated by the arrows.

The machine B (Fig. 118) is a saw for further dividing the bone into strips, and below the saw is a hopper K which guides the dust down to the branch pipe P, and thence through the main duct M to the fan F. Fitted in the hopper K is a slide S, which can be opened or shut to regulate the draught; this slide also serves to collect any splints or pieces of bone that would otherwise pass into the main duct and cause a noisy rattle in its passage. The machine C is a small tool for converting the rough strip of bones into a round rod. The tool is surrounded by a hood formed of a lower half T and a hinged upper half U, both so constructed as to guide the dust into the down pipe Q and thence to the main duct. The machine D is an emery wheel for sharpening the rods into pointed knitting needles, &c., and is covered by a metal hood. This hood is of the shape shown at *r*, and carries a loose flap of leather *x* over the wheel. The dust is drawn away in the direction shown by the arrows. Below the bench at E and on a level with the floor is a sweep hole, connected with the main duct and covered with a trap door when not in use; into this all the floor refuse can be swept at intervals and carried away with the other dust into the receiver. The fan F discharges its dust-laden air through the channel G to a cyclone dust separator in an adjoining outhouse. The general effect of this installation is remarkable. The air of the room was formerly in a perfect haze, and every article in the room was covered with dust; now the room is perfectly clear, and some six sacks of bone dust are passed through the fan into the receiver every week.



— Fig. 119. —

Section of Rough-Sawing Bench: showing specially devised Hopper for collecting Dust driven through hollow bone

— Fig. 118. —

Extracting Dust from Bone Sawing & Finishing machinery, by means of Centrifugal Exhaust Fan, with Special Hoods, Downspouts, and Tapered Metal Duct below Floor discharging into Cyclone Separator.

A. Roughing-Saw. B. Sizing-Saw. C. Paring machine.

D. Emery-Wheel. E. Sweep-hole (with lid) to receive Floor Refuse.

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PLATE XLV.

BLOWING AND SMOKE EXHAUSTING PLANT FOR SMITHS' SHOP.

Fig. 120

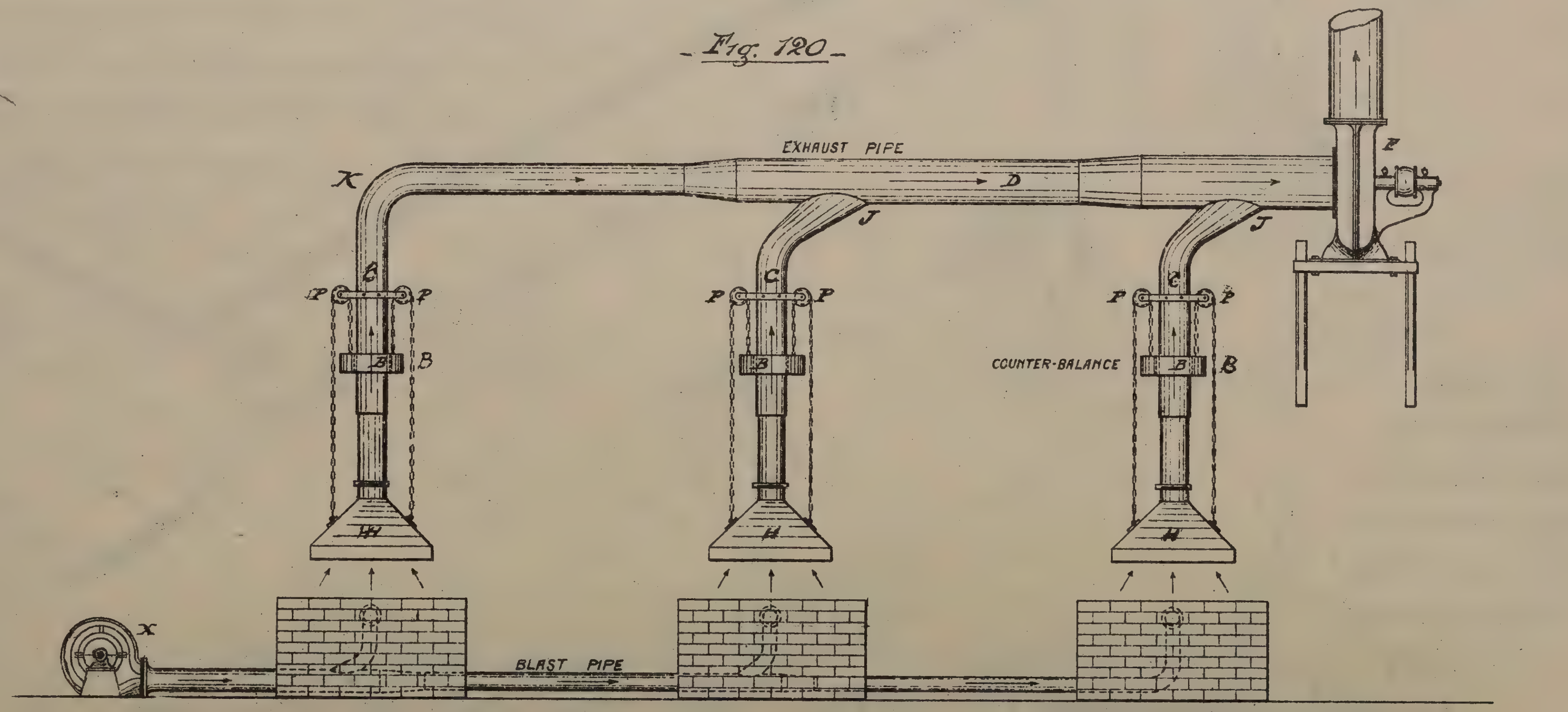

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PLATE XLV.

Removal of Smoke, &c.

(Drawn by H.M. Inspector, Mr. L. Ward, from design submitted by The Standard Engineering Co., Ltd., Leicester.)

Fig. 120 shows a very neat and satisfactory arrangement for exhausting smoke from a row of forges by means of a centrifugal exhaust fan F, the blast for the fires being also supplied by a centrifugal fan X. It will be seen from the drawing that the hoods HHH have telescopic necks, which fit into the uptakes CCC, and they are maintained in any required position by annular balance weights BBB suspended on chains over pulleys PP.

It will also be seen by reference to the experiments made by the Committee on exhaust fans and their connections (pp. 18–22) that this installation practically fulfils the conditions therein described as essential to equality and ease of air-flow through the branch ducts. The branch uptakes CCC are connected to the main duct by well turned and properly inclined junctions JJ, the furthermost branch being in fact a continuation of the main duct turned into the vertical position by a well-rounded curve K.

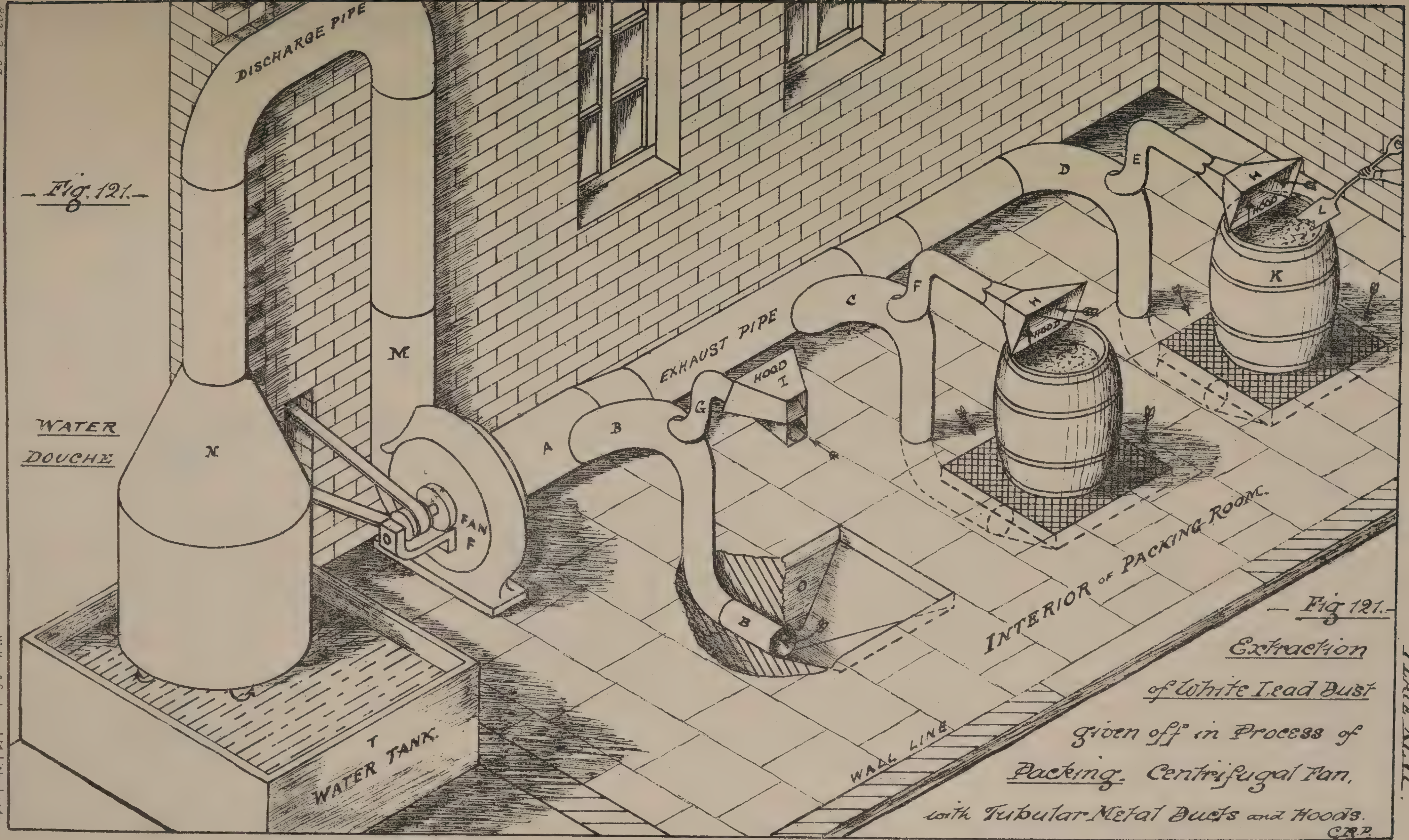
PLATE XLVI.

Removal of White Lead Dust.

(*Drawn by the Secretary from designs published by The Sturtevant Engineering Company, Ltd., London.*)

Fig. 121 shews one method of removing the highly injurious white lead dust which would otherwise be given off indiscriminately in the process of packing white lead into casks. Each cask is placed on a grid GG and these grids are themselves placed over a hopper-like receptacle O which is exhausted by means of the curved branch pipes B, C, D, which all lead into the main exhaust pipe A towards the fan F. Any dust therefore that falls over the edge of the cask is immediately drawn downwards and away from the filler. Not only this, but raised on the top of each cask is a hood H which can be hinged to throw back as shewn at I ; these hoods are connected by the upper curved branch pipes E, F, and G to the main system, and thus any dust arising in the top of the cask is also drawn away by that means. The fan F discharges its dust-laden air up through a discharge pipe M and out into a cone-like arrangement in another shed. This cone N contains a number of inclined slabs over which water is allowed to trickle, and the dust deposited by the blast on these slabs is washed down harmlessly into the water tank T, the spent air being allowed to issue from the bottom edge of the douche as shewn by the arrows.

PLATE XLVI.



– Fig 121. –

Extraction

of White Lead Dust

given off in Process of

Packing. Centrifugal Fan,

with Tubular Metal Ducts and Hoods.

C.R.P.

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PLATE XLVII.

EXTRACTION OF DUST FROM WHITE LEAD GRINDING PAN.

SCALE ½ INCH = 1 FOOT.

Fig. 122.

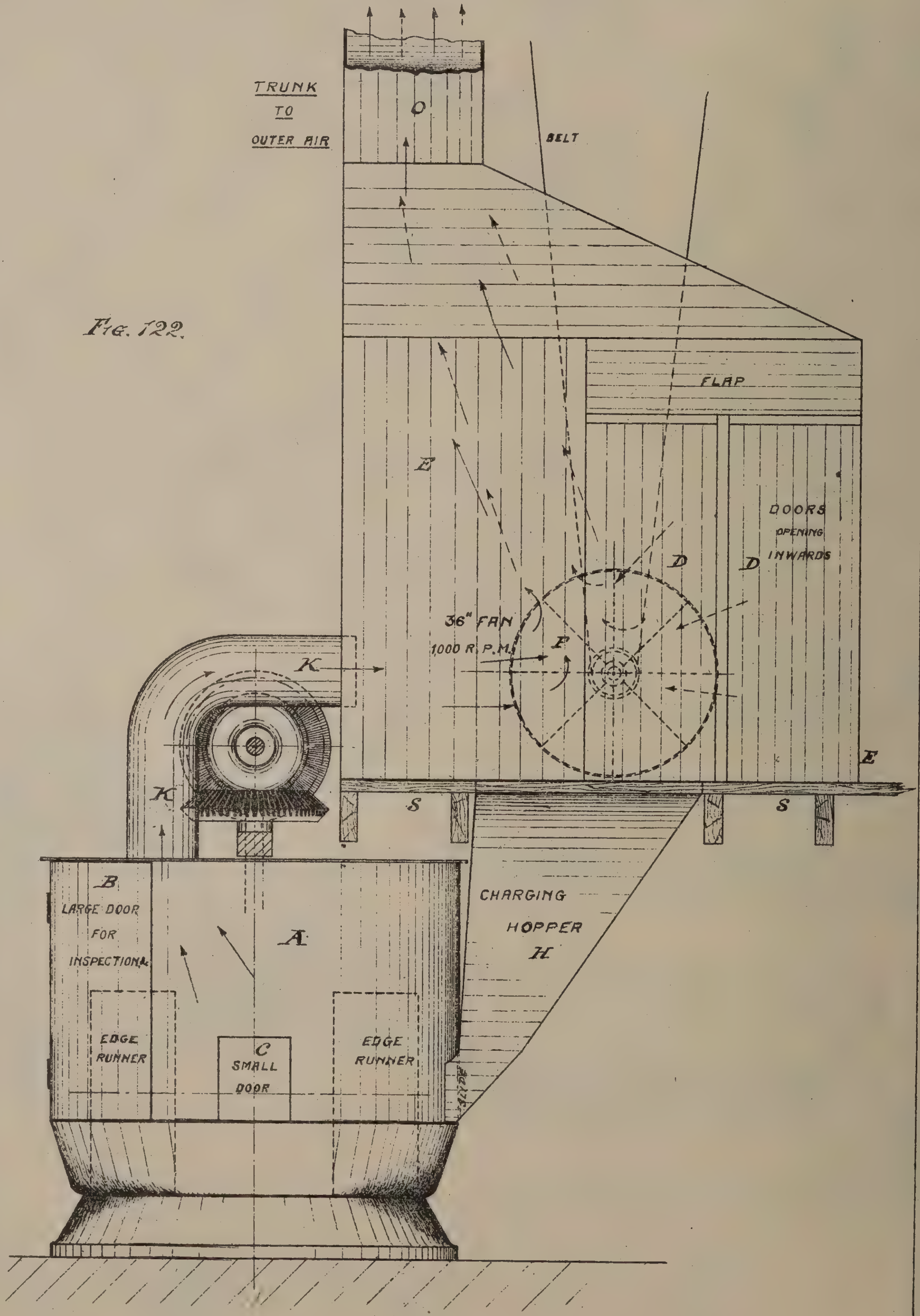

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PLATE XLVII.

Removal of White Lead Dust (*continued*).

(*Drawn by H.M. Inspector, Mr. L. Ward, from sketches furnished by Messrs. C. Hare & Co., White Lead Works, Bristol.*)

Another installation dealing with finished white lead is shewn in Fig. 122, the process being the grinding and mixing of white lead into paint by means of a Torrance mill. The mill itself is enclosed by a cover A having a large door B for the use of the attendant, and a small door C for the supply of oil, &c. The white lead cask is taken up to a stage S and placed mouth forwards in through the doors DD which open inwards into a chamber E in which there is a 36-inch propeller fan making 1000 revolutions per minute.

The cask is then tilted and its contents poured into a charging hopper H the mouth of which is immediately below the fan chamber E and opposite the fan itself, so that any dust given off by the charging process is immediately sucked away by the fan. When a convenient amount of lead is passed into the hopper H the doors DD are closed and the large door B is opened to see that the lead is properly distributed in the pan, but whilst this door is open air is forcibly drawn in and through the mill cover A by means of the 12-inch pipe KK which is also connected direct to the fan chamber. Thus the attendant is protected from dust at all periods and stages of the process.

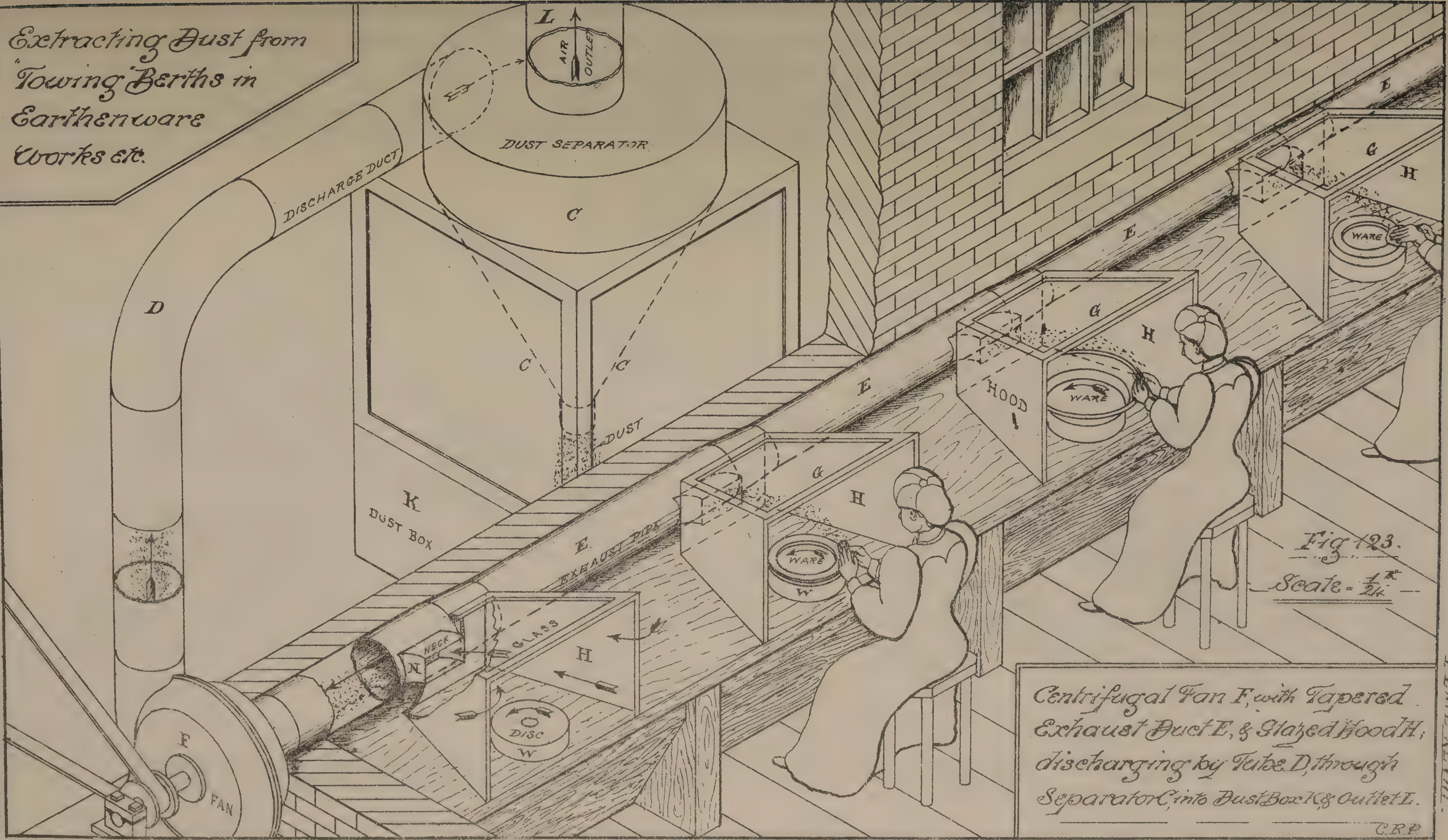
PLATE XLVIII.

Pottery Dusts.—Towing-Wheels, &c.

(*Drawing by the Secretary from system installed at Messrs. Pountney's Pottery, Bristol. Engineers: The Standard Engineering Company, Ltd.*)

The illustration Fig. 123 gives a general view of an arrangement for withdrawing dust from the towing benches in a large Pottery. The plates and dishes, &c. are placed on a small whirling disc W, and rapidly turned round. As they turn, a piece of tow, sand paper or other appliance is used to scour off the superfluous edges and unevenness, &c. The dust thus given off is injurious and needs to be carried away from the worker's person. This is accomplished by covering the ware placed on the whirling disc with a hood H, the top part of which is fitted with a glass pane to admit sufficient light. At the back of each hood there is a graduated opening N which leads immediately into the exhaust pipe EEE connected with a centrifugal fan F. This fan discharges its dust-laden air through a duct D into a dust separator of the cyclone pattern C: the dust being deposited in a box K below the cyclone nozzle, and the spent air emerging through the outlet L at the top. This installation is a successful departure from the usual system of wooden ducts with propeller fans.

PLATE XLVIII.



Extracting Dust from
"Towing" Berths in
Earthenware
Works &c.

Fig 123.
Scale = $\frac{1^{x}}{2k}$

Centrifugal Fan F, with Tapered
Exhaust Duct E, & Glazed Hood H;
discharging by Tube D, through
Separator C, into Dust Box K, & Outlet L.

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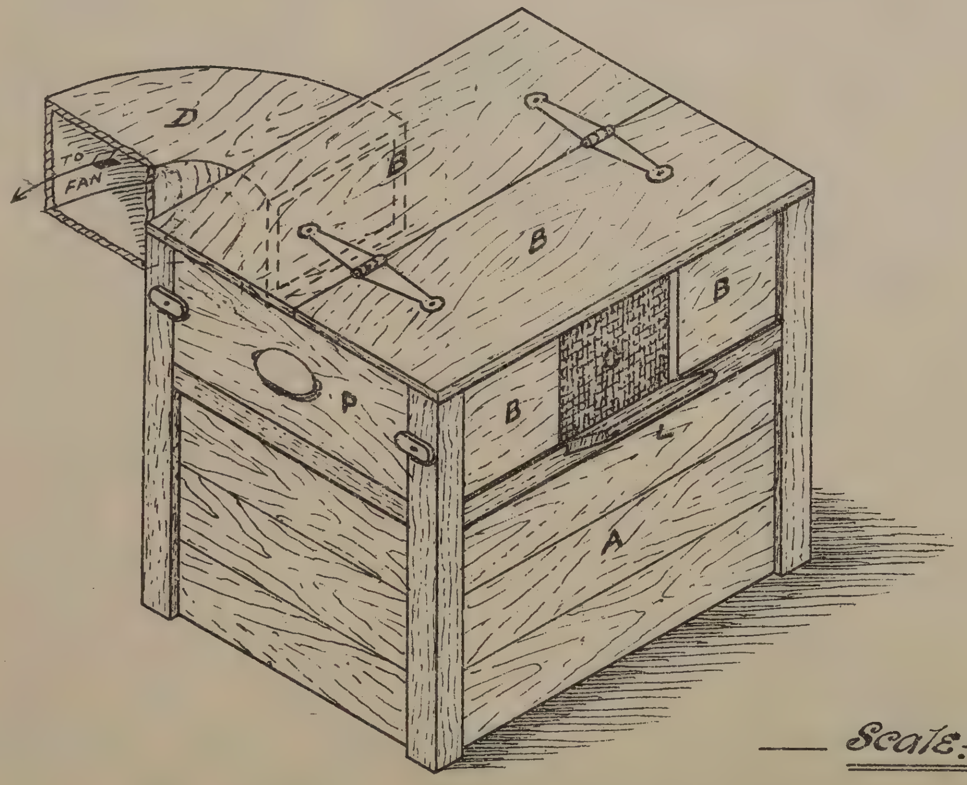
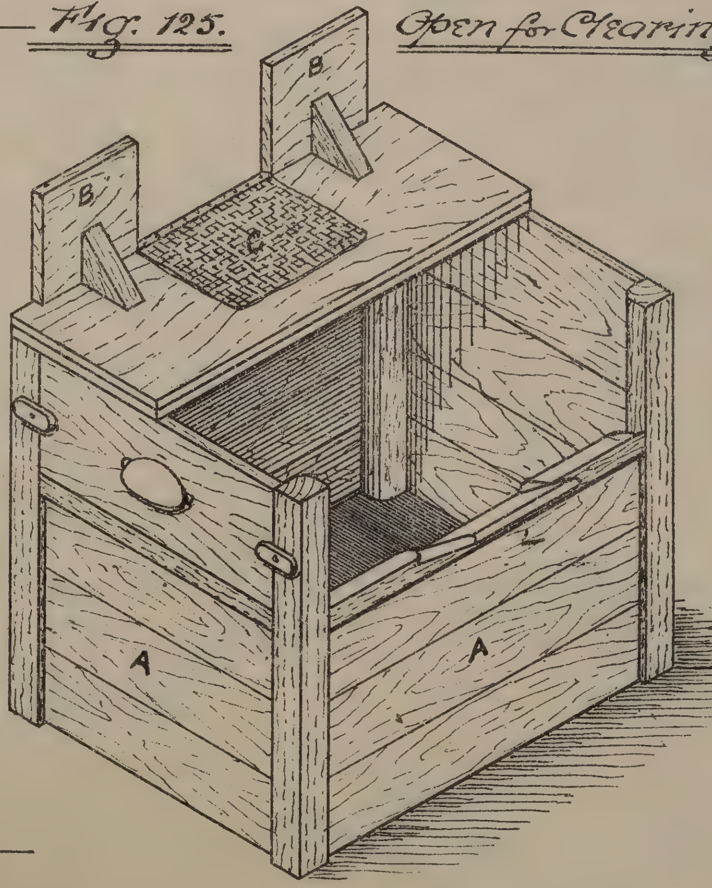
—Fig. 124. Cover Closed as in use.—



—Fig. 125. Open for Clearing.—



— Scale:-½in-1 FOOT —

China. Potteries. Prevention of Dust in "Flat-Knocking." A large Box A, has a double-hinged Cover BB, in which there is an opening, covered by a Gauze Cloth, C, secured at the top and hanging loosely over the hole. Through this the hands are placed when knocking the Flint Dust from Plates &c. The box A can be exhausted by propeller Fan by means of a duct at the back (See D. Fig 124).

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PLATE XLIX.

POTTERY DUST (*continued*).—FLAT-KNOCKING.

(*Drawn by the Secretary from sketch contributed by H.M. Inspector, Mr. J. H. Walmsley.*)

The box illustrated on this Plate is a contrivance used in many potteries to prevent the spreading of injurious dust in the process of flat-knocking, by which is meant the knocking of superfluous flint dust from plates, &c., by tapping them together between the hands. The lid of the box P is in two halves, the forward portion BB of which can be opened or shut. When closed, as in Fig. 124, a piece of gauze cloth C hangs down over the opening in front of the ledge L. The hands are placed through this opening when in the act of knocking off the dust, and immediately the hands are withdrawn the curtain C falls down to cover the hole. Fig. 125 shows the lid BB thrown back for the purpose of removing dust, &c., from the box, and while this is being done the box can be exhausted if necessary by means of a duct D at the back, connected with a fan.

PLATE L.

EARTHENWARE MANUFACTURE.—REMOVAL OF DUST FROM SANITARY WARE CLEANING.

(*System adopted by Messrs. J. and M. Craig, Ltd., Kilmarnock. Drawings submitted by The J. Keith and Blackman Co., Ltd., Engineers.*)

Fig. 126 shows the plan of an installation used for carrying off the dust which arises in the process of cleaning sanitary ware; and a feature of the arrangement is that one fan has to serve two rooms on different sides of the same wall and at different levels. The sectional elevation in Fig. 127 serves to show the relative position of these two rooms more clearly.

The propeller fan F is contained in a fan chamber G on the higher floor, and is in direct communication with a horizontal duct DD which extends along and behind a bench of some length in the same room. This duct accommodates 19 berths or work places, each of which is surrounded and surmounted by a hood H, under which the work is done in such a position that the dust given off is driven backwards and downwards away from the workers' faces.

A similar set of hoods KK on another bench in the lower room is connected by a branch duct I to the same fan F, and the dust-laden effluent from both rooms is discharged through the same opening.

PLATE L.

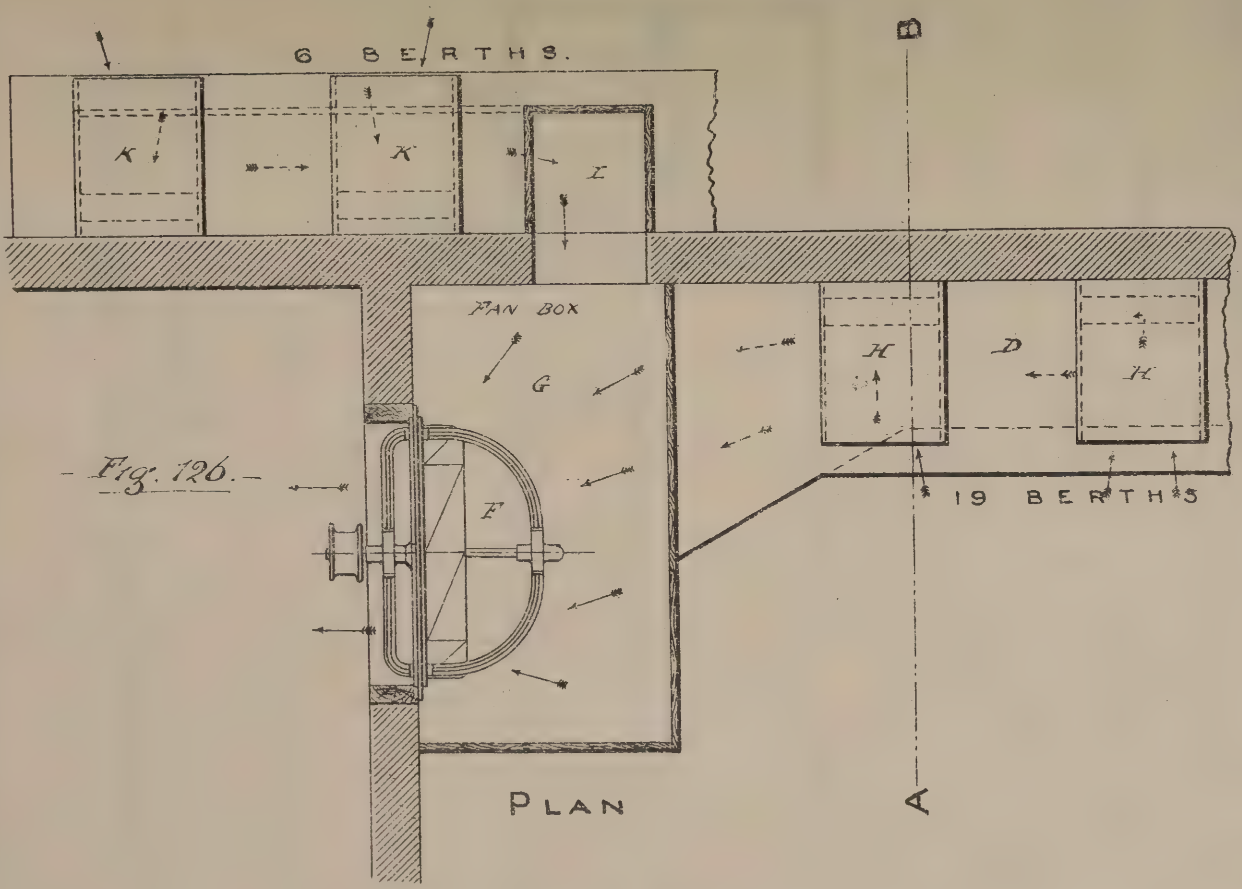

Fig. 126.

PLAN

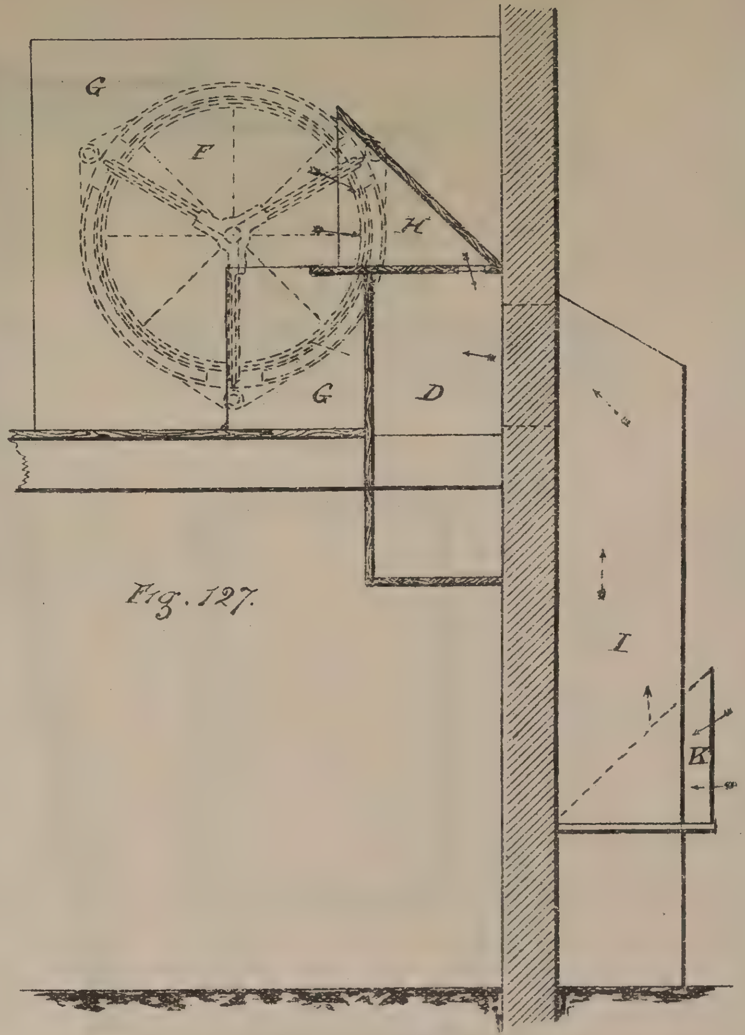

Fig. 127.

VENTILATING SANITARY WARE CLEANING BERTHS.

SECTION AB.

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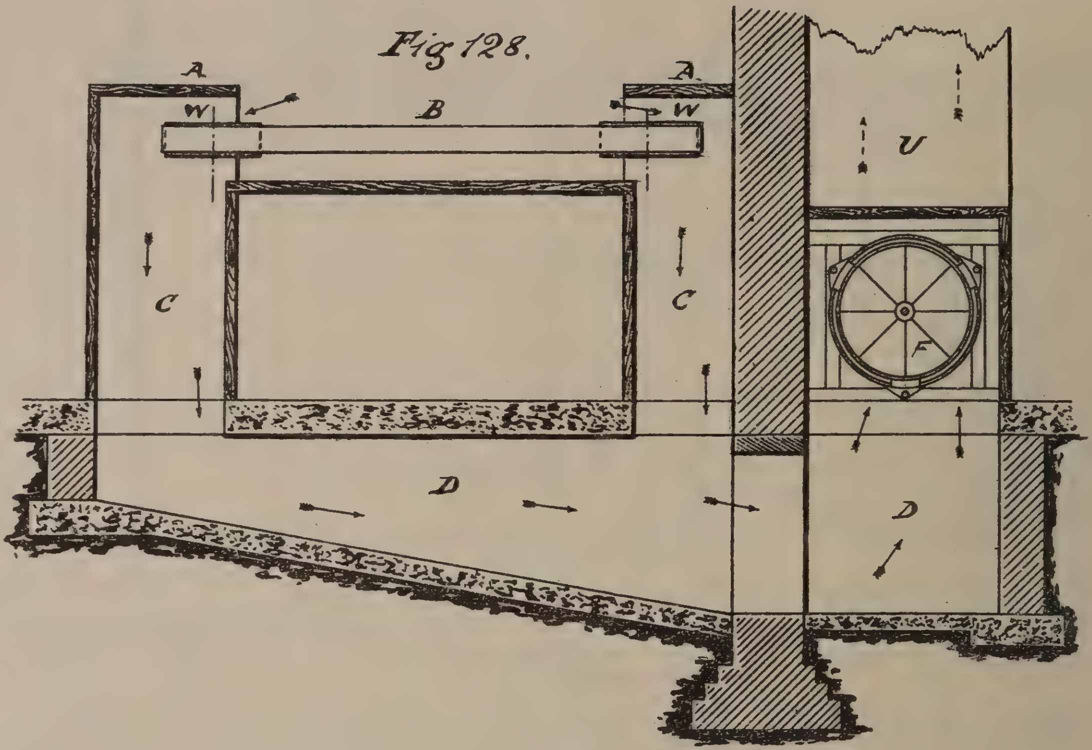
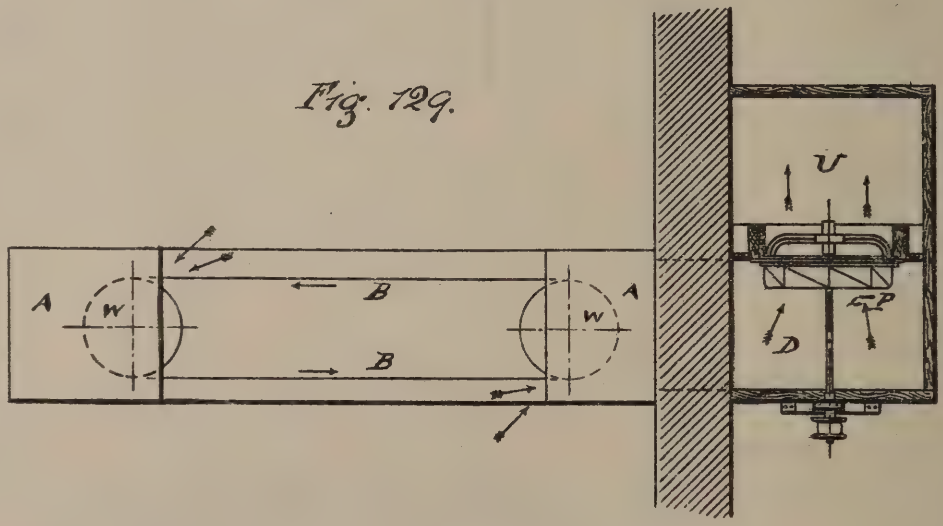
Fig 128.



SECTION.

Fig. 129.



PLAN.

REMOVING DUST FROM GLAZED BRICK GRINDING.

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PLATE LI.

GRINDING GLAZED BRICKS.—REMOVAL OF DUST.

(*System adopted by Messrs. J. and M. Craig, Kilmarnock. Drawings submitted by The J. Keith and Blackman Co., Ltd., Engineers.*)

Fig. 128 shows a sectional elevation of an arrangement for withdrawing the dust from an endless band which is used for grinding glazed bricks in the course of their manufacture.

The endless band B is carried on two wheels having vertical spindles, and these wheels are each partly covered by a board AA which also forms the cover of a vertical exhaust trunk CC. These two exhaust trunks are connected by means of an underground main duct DD to the fan F on the other side of the wall, by means of which the dust given off by the grinding belt B is conveyed through the uptake V to a proper point of discharge.

Fig. 129 shows the arrangement in partly sectioned plan, the same reference letters being used for each part.

PLATE LII.

Removing Fumes from Linotype Composing Machines.

(*Installation in use in the Composing Room of Messrs. C. Tinling & Co., Ltd., Proprietors of the "Liverprol Currier." Photographs by the Ventilating Engineers, Messrs. John Gibbs & Son, 72, Duke Street, Liverpool.*)

The installation here illustrated was carried out early in 1906, and being very successful in its results, has since been copied, with equal success, in other printing offices. It will be seen that the system consists of a long branch-fed middle tube or main duct, gradually tapering away from the fan and supported by the cross beams underneath the roof (*see* Fig. 130). The object of the installation is to remove the fumes arising from each melting pot on the various Linotype machines, which appear in the lower Fig. 131, and this is accomplished by placing over each pot a conical hood connected with a pipe, which first ascends vertically and then curves round at a suitable radius into the horizontal position shown in Fig. 130 ; from here it is carried to meet the main duct at an angle well inclined towards the fan. It will be seen from the general construction of the system that it embodies most of the principles and conditions already pointed out by the Committee as being essential to success in work of this character.

PLATE LII.

Removing Fumes from Linotype Composing Machines.

Centrifugal Fan and Tubular Metal Duct with Slanting Branches.

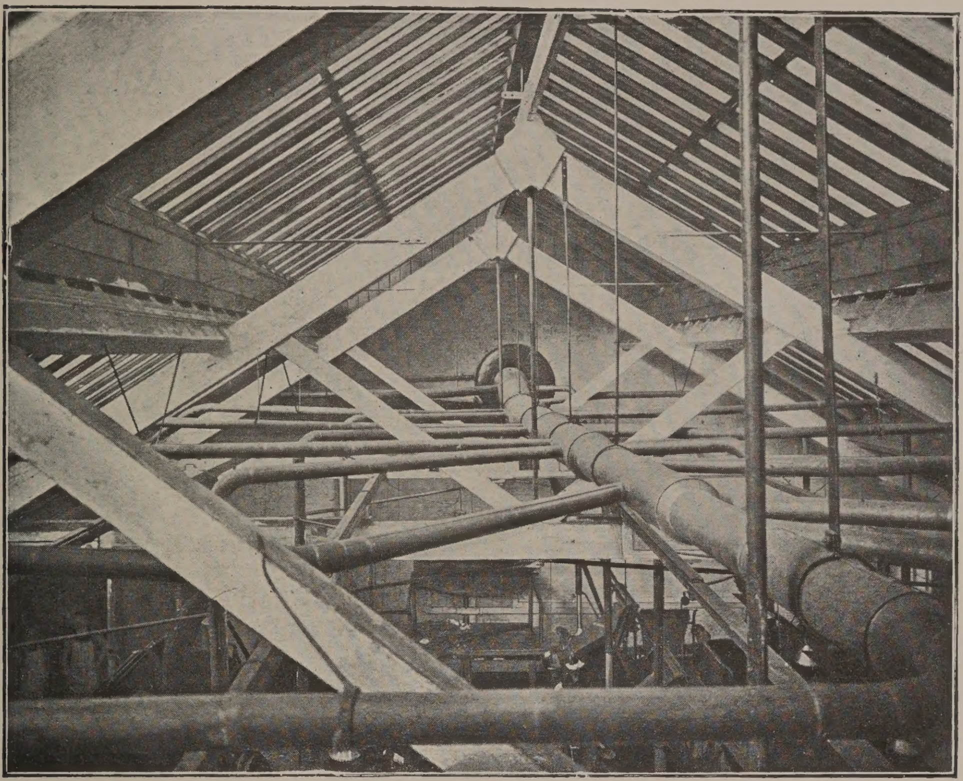

Fig. 130.—View of pipework from above.

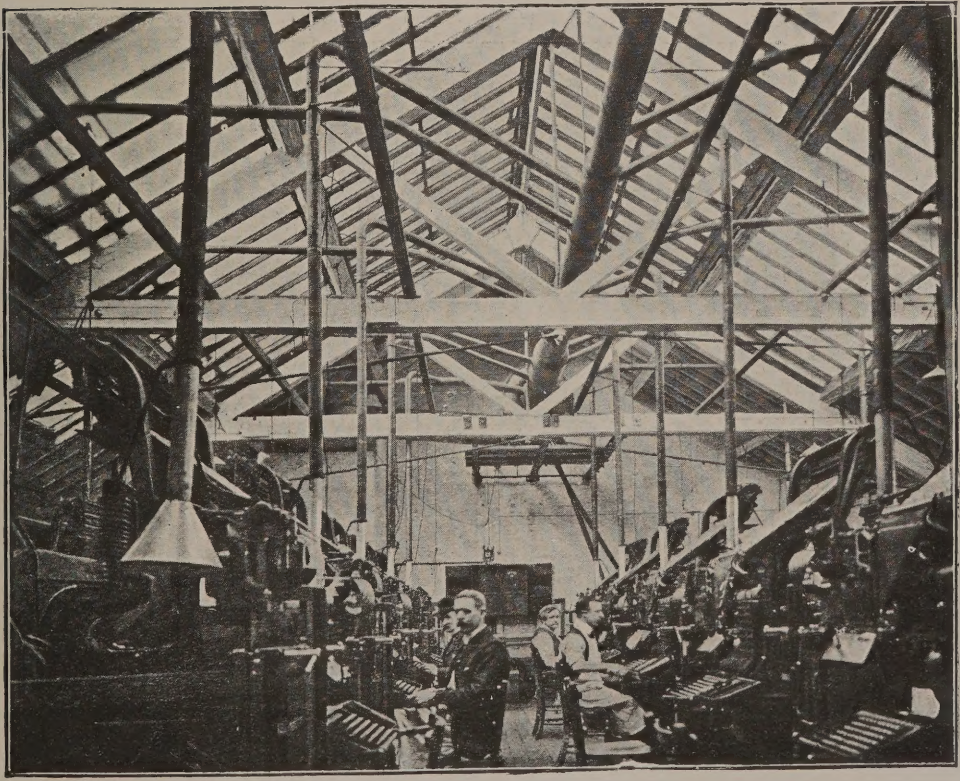

Fig. 131.—General view of machines and hoods over melting pots.

PLATE LIII.

Removing Dust from Rag-sorting Rooms.

Sirocco Fan and Tubular Metal Duct with Slanting Branches.

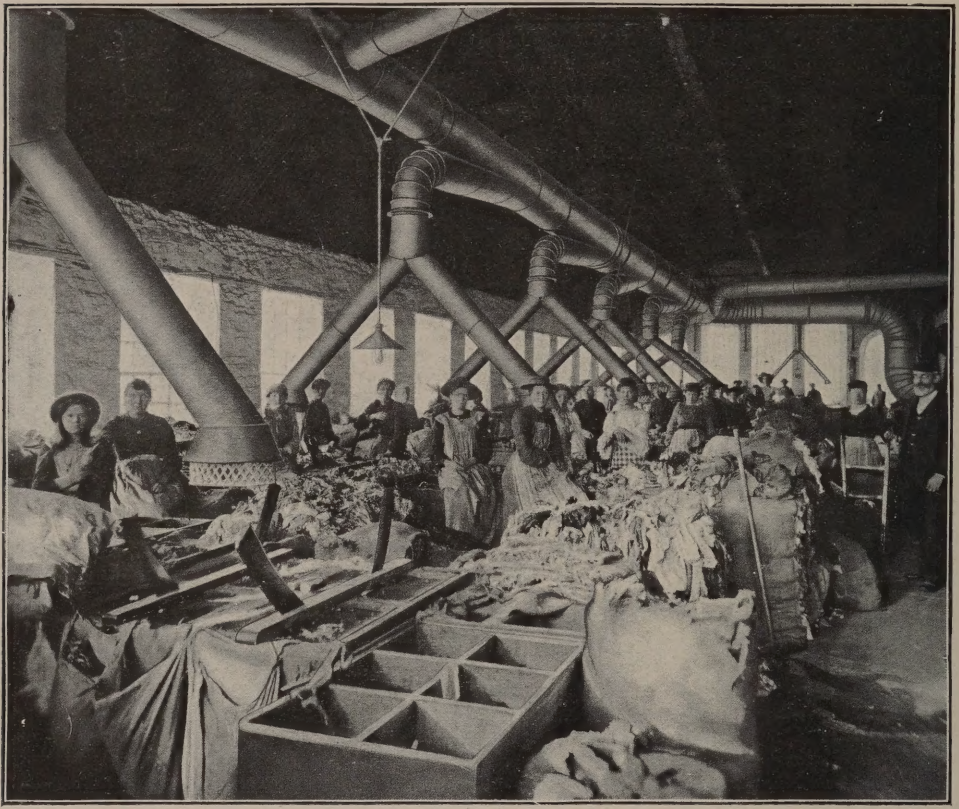

Fig. 132.—General view of room with workpeople.

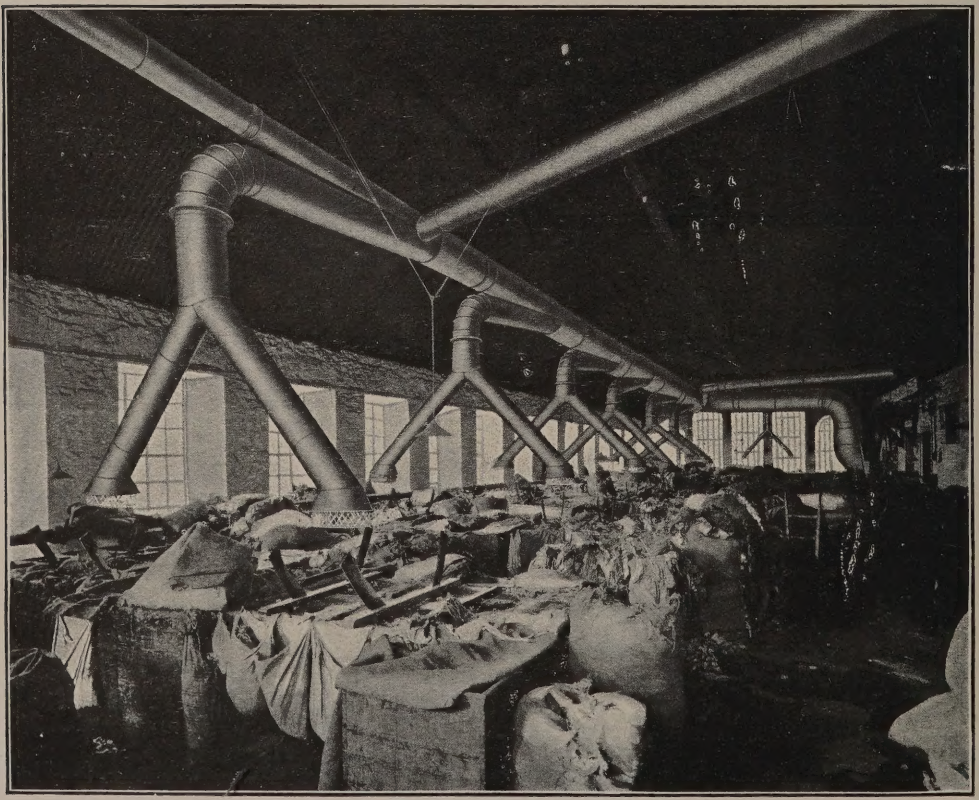

Fig. 133.—Clearer view of main and branch ducts.

PLATE LIII.

EXTRACTION OF DUST FROM THE RAG-SORTING DEPARTMENT OF A PAPER MILL.

(*Installation in use at the Golden Valley Paper Mill, Bitton, Gloucestershire; proprietor Mr. Charles King Smith. Photographs supplied by the Engineer, Mr. R. Stotesbury, Bristol, agent for Messrs. Davidson & Co., Ltd., Belfast.*)

The installation here shown is one of considerable interest, inasmuch as several schemes had previously been found impracticable owing to the difficult conditions under which it had to be erected. It is, of course, advisable wherever possible to use a downward current in removing dust of this character; but in this particular case it was not possible to lay a main duct below the floor level, as the flooring material could not be interfered with; neither was it possible to carry longitudinal ducts along the passage ways or beneath the tables, owing to the necessity of keeping a free gangway for the frequent transit of heavy trucks and bales. It was therefore necessary to use some kind of exhaust which would work in an upward direction, and the system finally adopted was that shown in Figs. 132 and 133. A large main tubular duct, 35 inches diameter at the fan and tapering down by steps at each junction to about 10 inches diameter at its extremity, is suspended from the tie-rods of the roof as shown, being kept sufficiently high to avoid interference with the light from windows; from this main duct a series of seven Y-shaped branches are suspended, each being coupled to the main duct by means of Sturtevant patent junctions or spring pieces, which enables the current from each tributary to enter the main at a very gentle inclination as shown. Each leg of these Y-shaped branches terminates in a slightly spreading hood, beneath which is attached a circular wire basket about five inches deep. These hoods are placed where they can best receive the dust arising from the rag-cutting operations, carried on by means of scythes placed vertically on wire-covered benches. Fig. 132 shows, in the foreground, a hood placed centrally above four such scythes. There are also special branches, each connected up to the dusting and rag-chopping machines, in order to extract all dust possible from these sources.

This installation, which was only completed at the end of 1906, has been so far very successful in effecting a marked improvement in the air of the room, as is easily tested by stopping the fan for a short time and then observing the cloudiness which soon arises, as compared with the clearness which immediately ensues when the fan is again started. Five minutes before the photograph shown in Fig. 132 was taken the fan had been stopped and the room was so full of dust that it was impossible to take it until the fan had been restarted, when the air rapidly became so clear that exceptionally good photographs were procured. The room itself measures approximately 100 feet by 30 feet by 14·6 feet (mean height), or roughly 43,500 cubic feet. The volume of air passing through each 9-inch suction pipe averages 720 cubic feet per minute, there being very little difference between the current near the fan and that at the far end of the room, this result being no doubt due to the special attention which had been given to all bends and junctions in accordance with the lessons learnt from the Committee's first series of experiments. The fan is a 35-inch Sirocco centrifugal cased fan running at 330 revolutions per minute and discharging a volume of about 24,000 cubic feet per minute. The room is intended for the occupation of 60 persons, of whom 50 were working when the photographs were taken, the number of rag tables being 17, in addition to 1 duster, 1 devil, and 1 cutter.

To warm the air in winter all air inlets to the rag house are closed except a narrow door-way about 18 inches wide and 6 ft. 6 ins. high placed mid-way in the long external wall on the opposite side to that occupied by the suction eyes of the exhaust system. In this narrow door-way a vertical high pressure steam radiator is placed in such a way that all air entering the room is warmed by it to any necessary extent, and so evenly is the inflow of warm air distributed over the room by the almost imperceptible currents produced by the suction eyes that no difficulty is experienced in ensuring a uniform temperature of 60°, or thereabouts, in all parts of the building, with wintry conditions prevailing outside.